THE PRINCIPLES OF PSYCHOLOGY

VOLUME I

THE PRINCIPLES OF PSYCHOLOGY

BY

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IN TWO VOLUMES

VOLUME I

NEW YORK AND LONDON
D. APPLETON AND COMPANY
1910

PREFACE TO THE THIRD EDITION.

This third edition of the *Principles of Psychology* differs from preceding editions, mainly by containing a new division; which occurs in the second volume, under the title —"Part VIII., Congruities."

By the preface to the first edition, it will be seen that I had originally intended to write, under the title of "Summary and Conclusion," a division having for its purpose "to bring the several lines of argument to a focus:" believing that "the harmony that may be shown to subsist between the doctrines elaborated in the respective divisions, is a strong confirmation of their truth." When I began to prepare the second and greatly enlarged edition, I looked forward to fulfilling this intention, which disturbed health had before obliged me to abandon. Eventually, however, I left the additional part unwritten—partly because the work had already become too bulky, and partly because I thought that the harmonies I proposed to point out were so conspicuous that all readers would perceive them.

This last reason proved to be ill-grounded. Far from recognizing the harmonies which I thought conspicuous, sundry critics have enlarged on the incongruities. In a review published in the *Academy* for April 1, 1873, Mr. Henry Sidgwick speaks of "the mazy inconsistency of his [my] metaphysical results." Similarly, a writer in the *Spectator* for the 21st of June, 1873, asserts that "Mr. Spencer's system has the incurable defect of fundamental incoherence." Prof. Green, also, in two articles which appeared in the *Contemporary Review* for December, 1877, and March, 1878, devotes much space to showing, as he thinks, that my views are not coherent. Thus I find it, if not necessary, at any rate desirable, to fulfil my first intention.

It is a common remark that where party feeling, political or theological, runs high, one who, believing that neither side is wholly right or wholly wrong, declines to commit himself entirely to either, is usually looked upon by both with suspicion, if not with aversion. And it is curious to see how, analogously, in a controversy so remote in its issues from human interests as that between Realism and Idealism, the enunciation of a view which recognizes an element of truth in each, seems to beget antipathy rather than sympathy. The adherents of either doctrine, believing that it is entirely true or entirely false, are averse to a conciliation which requires any sacrifice. Surrender of a part of their doctrine is almost as offensive to their *amour propre* as surrender of the whole; and the proposer of it is censured all round.

Recognizing, thus, the disfavour with which both Realists and Idealists naturally regard that Transfigured Realism which accepts from each a moiety of his doctrine but rejects the rest, I scarcely expect that where they before discovered only incongruities, this new division will show them that there are congruities. I can do no more than exhibit these, in the belief that they will be apparent to all who have not yet committed themselves to one side or the other. I may add that inability to recognize these congruities admits of two interpretations, conveniently suggested by a simile which I have before employed in another relation. Taken at different angles from the same object, the two photographs placed in a stereoscope, when first viewed, not unfrequently form a confused double image; but after persevering contemplation, most observers find them suddenly unite into a single clear representation of the object. Meanwhile, there are some eyes which to the last fail in combining them; and to which they continuously appear conflicting and confused.

LONDON, *October*, 1880.

PREFACE TO THE SECOND EDITION.

WORDS are somewhat strained in their meanings by calling that a Second Edition, of which the new portion greatly exceeds the old portion in amount; as happens with this volume, and as will happen with its successor. Of the five Parts here bound together, the two that have previously appeared cover 217 pages; while the three that now appear for the first time cover 425 pages.

Nevertheless, the fact that sundry of the cardinal ideas contained in this work were enunciated many years ago, must not be lost sight of. When, in 1855, the First Edition of *The Principles of Psychology* was issued, it had to encounter a public opinion almost universally adverse. The Doctrine of Evolution everywhere implied in it, was at that time ridiculed in the world at large, and frowned upon even in the scientific world. Naturally, therefore, the work, passed over, or treated with but small respect, by reviewers, received scarcely any attention; and its contents remained unknown save to the select few. The great change of attitude towards the Doctrine of Evolution in general, which has taken place during the last ten years, has made the Doctrine of Mental Evolution seem less unacceptable; and one result has been that the leading conceptions set forth in the First Edition of this work, have of late obtained considerable currency. In France, some of them have been made known incidentally by the treatise of M. Taine, *De l'Intelligence;* and the lucid exposition of Prof. Ribot in his *Psychologie Anglaise Contemporaine*, has presented them all in a systematic form. In England, they have spread through various channels. Among these I may more especially name *The Physiology and Pathology of the Mind*, by Dr. Maudsley, the first division of which work is pervaded by them. As most of those who will read this Second Edition of the *Principles of Psychology*, never saw the First Edition, and cannot now get access to it; and as, in Parts III. and IV., they will meet with ideas that have been already made, in the ways indicated, more or less familiar to them; it is needful that I should state these facts to prevent misapprehensions.

Part V., which closes this volume, is the Part referred to in the final paragraph of the Preface to the First Edition, as omitted for the reasons given. In now fulfilling the half-promise there made, eventually to add it to the rest, I have the satisfaction of feeling that during the fifteen years that have elapsed, the hypothesis set forth in it has assumed a much higher development.

The long delays in the issues of the successive portions of this work, have arisen in part from disturbances of health that have from time to time compelled me to desist from work, and in part from the continuous attention taken in arranging and superintending a systematic collection of materials for the *Principles of Sociology*, presently to be commenced. I have reason to hope that neither of these causes will operate so seriously in delaying the issue of the numbers which are to compose the second volume.

LONDON, *December*, 1870.

PREFACE.

The four parts of which this work consists,* though intimately related to each other as different views of the same great aggregate of phenomena, are yet, in the main, severally independent and complete in themselves. The particular serial arrangement in which they should be presented, has consequently been in great measure a question of general expediency; and while the order I have chosen is one which seems, on the whole, the most advantageous, it is not one which all readers are bound to follow. A brief characterization of each part, will enable every one to decide for himself which he may best commence with.†

The General Analysis (of which the essential portion was originally published in the *Westminster Review* for October, 1853, under the title of "The Universal Postulate," and reappears here with additional arguments and explanations) is an inquiry concerning the basis of our intelligence. Its object is to ascertain the fundamental peculiarity of all modes of consciousness constituting knowledge proper—knowledge of the highest validity.

The Special Analysis has for its aim, to resolve each species of cognition into its components. Commencing with the most involved ones, it seeks by successive decomposi-

* The number of parts is now greatly increased: this volume contains five, and the second volume will contain four.

† The order has now been wholly changed: the two parts immediately named as coming first, being relegated to the second volume.

tions to reduce cognitions of every order to those of the simplest kind; and so, finally to make apparent the common nature of all thought, and disclose its ultimate constituents.

While these analytical parts deal with the phenomena of intelligence subjectively, and, as a necessary consequence, are confined to human intelligence; the synthetical parts deal with the phenomena of intelligence objectively, and so include not human intelligence only, but intelligence under every form.

The General Synthesis, setting out with an abstract statement of the relation subsisting between every living organism and the external world, and arguing that all vital actions whatever, mental and bodily, must be expressible in terms of this relation; proceeds to formulate, in such terms, the successive phases of progressing Life, considered apart from our conventional classifications of them.*

And the Special Synthesis, after exhibiting that gradual differentiation of the psychical from the physical life which accompanies the evolution of Life in general, goes on to develop, in its application to psychical life in particular, the doctrine which the previous part sets forth: describing the nature and genesis of the different modes of Intelligence, in terms of the relation which obtains between inner and outer phenomena.

As may be supposed, the analytical divisions are much less readable than the synthetical ones. Hence, while all who are accustomed to studies of an abstract character are recommended to follow the order in which the parts stand, as being that most conducive to a clear understanding of the system in its ensemble; those who are unfamiliar with mental philosophy may, perhaps, more advantageously begin with Parts III. and IV.: returning to Parts I. and II. should they feel sufficiently interested to do so.

* A portion of the Part thus described, is now embodied in *The Principles of Biology*.

Respecting the execution of the work, I may say that in sundry ways it falls much short of my wishes. There are places in which the argument is incompletely carried out; places in which, from inadequate explanation, there is an apparent incongruity between the statements there made and those made elsewhere; and there are, I fear, places where the form of expression is not so precise as it should be. Add to which, that in treating under several separate aspects a subject so extensive, I have perhaps erred in attempting too much; and have so devoted neither thought enough nor space enough to any one of the several aspects under which the subject is presented.

While, however, I am conscious that the work contains many more imperfections than it would have done had its scope been more limited and its elaboration longer, I would excuse the issue of it in its present form on several grounds: partly on the ground that it is almost useless to wait until any organized body of thought has reached its full development, which it never does in the course of a single life; partly on the ground that it is next to impossible for the writer of a work like this, to dispense with the aid of candid criticism; but chiefly on the ground that the general truths enunciated, being, as I believe, both new and important, it seemed to me undesirable to delay their publication with the view of by and by presenting them in a more finished guise.

For the somewhat abrupt termination of the work, my apology must be, that disturbed health has obliged me to desist from writing a "Summary and Conclusion," in which I purposed to bring the several lines of argument to a focus. I greatly regret this; not only because the harmony that may be shown to subsist between the doctrines elaborated in the respective divisions, is a strong confirmation of their truth; but because, in the absence of explanation, some misunderstanding may arise concerning the implications—ontological and other—which many will think manifest.

It may be well further to say that, originally, I had intended to add a fifth division, which should include sundry deductions and speculations that could not properly be embodied in the other divisions. But before being compelled to do so, I had decided, that as this fifth division was not strictly necessary; and as certain of the suggestions contained in it might prejudice some against the doctrines developed in the others; it would be better to withhold it—at any rate for the present.

July, 1855.

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PART I.

THE DATA OF PSYCHOLOGY.

CHAPTER I.

THE NERVOUS SYSTEM.

§ 1. The lowest animal and the highest animal present no contrast more striking than that between the small self-mobility of the one and the great self-mobility of the other. A monad passing, apparently with some rapidity, across the field of the microscope, really advances with extreme slowness: its velocity, unexaggerated by combined lenses, being about that of the minute-hand of a watch. The parts of a disturbed sea-anemone draw themselves together with a speed which, though immensely greater than that of a monad through the water, is insignificant as measured by the speed of most terrestrial and aerial creatures. Comparing the movements of *Protozoa*, or of *Zoophytes*, with those of Birds that keep pace with railway trains or those Mammals that gallop a mile in a minute, their locomotive powers seem scarcely appreciable. Masses being supposed equal, the quantity of motion generated in the last case approaches a million times that generated in the first.

Contrasts of this kind exist within each great division of the animal kingdom, as well as in the animal kingdom taken as a whole. The sub-kingdom *Annulosa* shows us an immense difference between the slow crawling of worms and quick flight of insects. Among Mollusks the sluggishness of the *Tunicata* is no less marked than the activity of the *Cephalopoda*. And between the inferior or water-breathing *Vertebrata* and superior or air-breathing *Vertebrata*, there is an equally conspicuous unlikeness in energy of movement.

This self-mobility which by its greater amount generally distinguishes higher animals from lower, and, indeed, enters largely into our conceptions of higher and lower, is displayed in several ways. We see it in the changes of attitude that are made without moving the body from place to place. We see it in the transference of the body as a whole through space: considering this transference apart from external resistances overcome. And we see it in the overcoming of resistances—both those of media and those due to gravity. All these, however, are manifestations of one ability—the ability to generate a force which either shows itself as momentum or would generate momentum but for a counterbalancing force. And it is in this general form that we are here concerned with this ability. We have to contemplate the inferior animals as being generators of very small quantities of actual or potential motion, and the higher animals as being generators of relatively-immense quantities of actual or potential motion.

§ 2. With what internal differences are these differences of external manifestation connected? No doubt with several. An active organism contains various appliances no one of which can be spared without greatly diminishing, or quite destroying, its activity.

If the alimentary system be incapacitated, there must presently result a decreased power of generating motion, from lack of the materials whence motion is obtained; and hence the fact, conspicuous throughout the animal kingdom, that along with much locomotive activity there goes a developed apparatus for taking up nutriment. It is manifest, too, that there cannot be great self-mobility unless the absorbed materials are efficiently distributed to the organs which transform insensible motion into sensible motion; and thus it happens that as we ascend from creatures which move little to creatures which move much, we meet with a more and more evolved vascular system. Similarly with the organs for separating from the blood the substances that have yielded up their contained motion. If the blood becomes choked with inert matter, there necessarily results a decreased genesis of motion; and therefore, as we see on comparing inactive with active animals, the exaltation of activity is accompanied by the development of depurating structures. Still clearer is it that the production of much motion, and the resistance to those forces which antagonize motion, imply parts capable of bearing great strains—masses of dense tissue such as in vertebrate animals form bones, and in invertebrate animals form dermal frameworks; and, accordingly, as we ascend from creatures that are inert to creatures that are vivacious, we advance from weak to strong skeletons, internal or external. Above all it is self-evident that along with locomotive activity there must exist those contractile organs which are the immediate movers of the limbs and consequently of the body; and hence the direct connection between absence of muscular fibres and extremely-small self-mobility, and the direct connection between development of the muscles and much self-mobility—connections so direct as to make it at first sight seem that the genesis of motion varies as the muscular development.

Remotely dependent, however, as the genesis of motion is on digestive, vascular, respiratory, and other structures; and immediately dependent as it is on contractile structures; its most important dependence remains to be named. For all of these appliances taken together can do nothing of themselves. The muscles are but instruments, which remain passive until their power is evoked by the structure which uses them; and the quantity of motion they then give out varies according to the demand made by this exciting and controlling structure. In other words, the initiator or primary generator of motion is the Nervous System. Where there is extremely little power of generating motion, as among the *Protozoa* and the inferior *Cœlenterata*, there is no nervous system. Where activity begins to show itself a nervous system begins to be visible. And where the power of self-movement is great, the nervous system is comparatively well developed. Though the muscular system also becomes larger and better organized; yet the quantity of motion produced is fundamentally related to the degree of nervous development. Not, indeed, that it is so related with anything like uniformity: this we shall presently see that it cannot be. But it is so related more uniformly than in any other way. A few typical contrasts will show this.

§ 3. The absence of measurements renders detailed comparison among the various classes of *Mollusca* unsatisfactory. On putting side by side the extreme terms, however, we find an unquestionable difference in the proportion between the nervous system and the rest of the body. The sedentary Ascidians, which do little in the way of moving beyond occasionally contracting themselves, severally possess only a single small ganglion with its fibres; but Cephalopods of the dibranchiate order, which are active creatures that dart through the water fast enough to catch fish, contain masses of nerve-tissue that bear much larger ratios to their total masses.

It is with annulose animals as with molluscous animals—we have no definite estimates of the sizes of their nervous systems; and hence can bring in evidence only the marked differences. As before, the extreme forms supply these. The sluggish annuloid types, when contrasted with the energetic kinds of *Annulosa*, present decided deficiencies of nerve-substance; and even between such less-remote orders as the tubicolous Annelids, leading stationary lives, and the decapodous Crustaceans, leading active lives, a kindred difference may be safely asserted. There are also, in some annulose types contrasts between the nervous system in the inactive and active stages of the same individual. The feebly-moving caterpillar has but a small nervous system; the butterfly, with its power of vigorous flight, has a relatively large one; and during the intermediate pupa-state, in which the organization is being adapted to this more vivacious life, a rapid growth of the nervous system may be traced.

It is in the *Vertebrata*, however, that the most striking evidence meets us. According to Leuret, the average ratio of the brain to the body is—in fishes, 1 to 5,668; in reptiles, 1 to 1,321; in birds, 1 to 212; and in mammals, 1 to 186. Now though these can be but rude approximations, since there are great differences within each class, and since the ratio of the brain to the body is not the ratio of the whole nervous system to the body; yet the relations they indicate are substantially true. Were the weight of the spinal cord and the nerves added to that of the brain in each case, the strengths of the contrasts would be considerably diminished; but the contrasts would still be strong. And with them there go the strong contrasts between the activities in the respective classes—the Fishes that swim in a medium of their own specific gravity; the Reptiles of which the higher have to support the weights of their bodies as they move about over the land, but cannot do this for long together; the Birds and Mammals that are in constant locomotion, often at high velocities. Here, too, the alleged connection is rendered the clearer by the approximate uniformity of the relative amount of muscle. The weight of muscle in a fish forms something like as large a part of the total weight as it does in a reptile—perhaps a larger part; and a reptile is scarcely if at all inferior to a bird or a mammal in the proportion of contractile tissue it possesses. Hence it becomes manifest that indispensable as is contractile tissue to the genesis of motion, its quantity does not determine the quantity of motion generated. Whereas, notwithstanding the many complicating circumstances, a general relation between quantity of nerve and quantity of motion is traceable.

There are special cases which illustrate this relation. I may name one—the case of the Porpoise. A Porpoise's brain exceeds greatly in size the brains of other Mammals that have bodies commensurate with its own, except that of Man and, perhaps, that of the Gorilla. Such a structure in a creature leading so simple a life, is a serious difficulty in the way of current interpretations; but is quite in harmony with the interpretations here given. Porpoises accompanying a steam-vessel, gambolling and making excursions on either side without apparent effort, prove, by keeping up so high a velocity through so dense a medium, that their motor energies are enormous.

§ 4. A closer examination of the facts soon reveals the insufficiency of the foregoing generalization. Deep as is the connection between nervous development and locomotive activity, further comparisons show that it is complicated with some other connection scarcely less radical. If, other things being equal, the quantity of motion generated varied directly as the quantity of nerve-tissue, then, in creatures constitutionally alike or but little dissimilar, a tolerably constant ratio would exist between the mass of the nervous system and the mass of the body: supposing the body, whether large or small, to be carried from place to place with equal velocity. The ratio is far from constant however.

A horse gallops much faster than a man runs; and a horse in ordinary work daily moves his body through a space greater than that through which a man moves his body, or greater than that transposition of his body which a man's daily labour is equivalent to. Hence were there a simple relation between amount of nerve-tissue and amount of motion evolved, a horse, which weighs some seven times as much as a man, should have a nervous system at least seven times as heavy. Instead of this it has a lighter nervous system. Its brain weighs but one pound seven ounces; and were its spinal cord added, the total weight would probably not exceed two pounds. But a man's brain and spinal cord weigh between three and four pounds. Thus the horse's cerebro-spinal axis is but one-tenth of what it should be, were this relation the only one. Still clearer is the proof that there is some other relation, when we avoid modifying causes, by comparing animals of the same genus, or species, but of different sizes. The varieties of dogs supply good illustrations. A newfoundland and a spaniel are alike in organization, food, temperature, respiration, &c.; and they are approximately alike in their powers of locomotion: the advantage being on the side of the larger of the two. Were genesis of motion measured by quantity of nerve-tissue, a newfoundland's cerebro-spinal axis should, therefore, exceed in size that of a spaniel as much as a newfoundland's body exceeds in size that of a spaniel. But it by no means does so. While considerably larger absolutely, it is much smaller relatively.

Consequently, we must say that though the nervous system is the initiator of motion, and though there is evidently some relation between degree of nervous development and degree of motor energy; yet this relation is involved with, and obscured by, another. Let us re-examine the facts in search of it.

§ 5. In what other way than in relative feebleness, do the motions of inferior creatures differ from those of superior creatures? They differ in relative simplicity. Animals that are but little evolved perform actions which, besides being slow, are few in kind and severally uniform in composition. Animals that are much evolved perform actions which, besides being rapid, are numerous in kind and severally involved in composition. The movements in the one case are small and homogeneous, and in the other case great and heterogeneous. Each sub-kingdom of animals exemplifies this second general relation, as much as it does the first.

Humble Mollusks, like the fixed *Tunicata*, display scarcely any energies beyond those required to contract their bodies when disturbed and afterwards to unfold them. But in the highly-organized Cuttle-fishes, besides the rapid, quickly-varied, and well-adjusted movements exhibited in the pursuit and capture of prey, we have the numerous and combined movements of the suckered arms, used not only for prehension but occasionally for travelling over solid surfaces. The *Annulosa*, including with them the *Annuloida*, supply a like general contrast. Between the uniform, little-varied motions of a Nemertine worm, and the multiform, variously-combined motions of the Crab or the Spider, the difference is paralleled by the difference in nervous evolution. And a like structural contrast accompanies the contrast between the few simple actions of the caterpillar and the numerous complex actions of the butterfly.

But that heterogeneity of movement increases along with relative size of the nervous system, is best shown by comparisons among vertebrate animals. Progressing by alternate contractions of its lateral muscles, and opening its jaws to take in food and water, the Fish adds to these little else but those undulations of the fins and tail that serve to balance and turn it. A Reptile, using its limbs in the water or on land or both, performs muscular actions considerably more varied and more combined; but still, actions that are directed to comparatively few ends. An ordinary Mammal exhibits in the chase and destruction of prey, in the making of burrows, in the rearing of young, in the laying up of food, a greater variety of actions that are severally more compound. On arriving at the higher Mammals, ending with Man, we meet with motions that are almost countless in their kinds, that are severally composed of many minor motions accurately adjusted in their relative quantities and successions, and that are themselves compounded into courses of action directed to multiform objects. And with each such increment of complexity in the motor functions throughout the *Vertebrata*, there goes an increment of nervous endowment.

This, then, is the secondary connection which traverses and complicates the primary connection. We saw that were there no other relation than that between quantity of nerve-tissue and quantity of motion generated, a Horse should have a far larger nervous system than a Man, instead of having a smaller one. But finding that there is also a relation between quantity of nerve-tissue and complexity of motion, we are led to expect an exceptionally large nervous system in Man; and are enabled to understand why he has a larger one than a Horse has. More obvious, because not involved with irrelevant differences, is the interpretation thus yielded of the general rule, already illustrated in the case of the Dogs, that in each natural group or order of Mammals, the nervous systems do not increase in the same ratio as the bodies. We will glance at another illustration of this, supplied by the *Primates:* specially instructive because of the significant exception it contains, and specially interesting because that exception is furnished by mankind.

The small monkeys have relatively very large brains—larger relatively than the brains of their congeners, including even the highest. This connection, parallel to that presented in the spaniel and the newfoundland, has a parallel explanation. The movements of the little Capuchin monkey are approximately as varied and complex as those of the great Gorilla; and hence, in so far as nervous evolution is related to heterogeneity of motion, the Capuchin should have a nervous system differing but little in size from that of the Gorilla. But since there is also a relation between quantity of nerve and quantity of motion generated, the Gorilla's nervous system must be absolutely greater though relatively smaller: which we find it to be. Between the Gorilla and Man, however, there exists a converse contrast. Heavier than a Man, and moving about in the trees, a Gorilla probably generates daily as much motion as a savage, or as a civilized labourer; and were it the sole function of nerve-tissue to originate motion, should have at least as large a nervous system. But the nervous system of Man is twice as heavy. Here, therefore, all other relations being substantially the same, and the physiological processes being approximately alike in the two cases, the relative largeness of the human nervous system stands clearly related to the relatively-enormous complexity of human actions—a complexity shown partly in the more compound simultaneous movements, but mainly in the combination of successive movements, simple and compound, directed to remote ends.

§ 6. This double relation must still be taken as approximate only. Seeing as we did at the outset that the genesis of motion depends on many physiological conditions, of which each is separately variable, it is manifest that the fundamental connections we have traced must have sundry minor irregularities. Without treating of these in detail, it may be well to instance one—that due to difference of bodily temperature. Birds as a class are more active than Mammals as a class; and though many Mammals go through motions more heterogeneous than those of Birds, yet the inferior Mammals can scarcely be said to exceed Birds in the heterogeneity of their motions. Nevertheless, the nervous systems of Birds are relatively somewhat smaller than the nervous systems of Mammals. The explanation is that Birds have a higher blood-heat with its accompanying more active respiration—both implying a greater rate of molecular change. And a greater rate of molecular change enables a smaller nervous system to generate an amount of motion which would require a larger nervous system if the rate of molecular change were less.

A further qualifying fact to be here named is that, all other things being equal, the power of a nervous system does not vary exactly as its mass. For reasons that will hereafter appear, its efficiency as a motor agent increases in a somewhat higher ratio than the quantity of matter it contains.

But after all modifying causes have been allowed for, there remain substantially intact the fundamental relations set forth—namely, that wherever much motion is evolved, a relatively-large nervous system exists; that wherever the motion evolved though not great in quantity is heterogeneous in kind, a relatively-large nervous system exists; and that wherever the evolved motion is both great in quantity and heterogeneous in kind, the largest nervous systems exist.

§ 7. It is with deliberate intention that I have set out with this unfamiliar and, as many will think, somewhat strange presentation of the facts. My reasons for doing so are several.

One of them is that we are here primarily concerned with psychological phenomena as phenomena of Evolution; and, under their objective aspect, these, reduced to their lowest terms, are incidents in the continuous re-distribution of Matter and Motion. Hence the first question respecting the nervous system as studied from our point of view is—what are the leading facts it presents as expressed in terms of Matter and Motion?

Another reason is that, apart from any doctrine of Evolution, true conclusions respecting psychical phenomena must be based on the facts exhibited throughout organic nature; and that the above statement does literally nothing else than express these facts—expresses, too, all that direct induction can tell us respecting their essential relations.

The actions of all organic beings, including those of our own species, are known to us only as motions. Shutting out our inferential interpretations, the leaps and doublings of the escaping prey in common with the variously-adapted and rapidly-changed actions of the pursuer, are, to our perceptions, nothing but movements combined in particular ways; and so too are the changes of expression, tones of voice, and verbal articulations of our fellow-beings, on which we put such hidden implications. As, then, science requires us to distinguish the facts as actually presented from the suppositions we ordinarily join with them, it is needful to exhibit, in all its nakedness, this primordial relation between the external motions and their internal originator.

Yet a further reason for setting out thus, is that we so escape from pre-conceptions. Those who bring with them to the investigation of psychical phenomena, the hypotheses that have descended to us from the past, are almost sure to be more or less biassed thereby. While intending to avoid assumptions they are in great danger of having their conclusions vitiated, if not by some ancient or mediæval idea under its overt form, yet by corollaries from it that have unobtrusively embodied themselves in unsuspected postulates. As we shall presently see, even physiologists have been in some cases thus misled.

Hence, then, without at all calling in question the truth of those other and quite different interpretations of nervous phenomena that are tacitly expressed in ordinary language, it is proper for us here to ignore them. Before studying the facts from a psychological point of view, we have first to study them from a physiological point of view. The primary truth disclosed by the facts as so studied, is the universality of this relation between the degree of nervous evolution and the quantity and heterogeneity of the produced motion. We now pass to the secondary truths similarly disclosed.

CHAPTER II.

THE STRUCTURE OF THE NERVOUS SYSTEM.

§ 8. An outline of nervous structure must precede a detailed account of it; and the essential facts to be indicated in an outline may be brought most clearly into view by comparing with one another the nervous systems possessed by different types, and by different grades of the same type. We will limit our comparisons to the three superior sub-kingdoms of animals.

A minute nodule with diverging threads constitutes the rudimentary nervous system, as existing in the lowest Mollusk. In the Lamellibranchs several such minute nodules, or ganglia, are distributed, usually in pairs, in different parts of the body; and beyond the free fibres which they severally give off to neighbouring organs, there are fibres by which they are connected together. Gasteropods, considerably higher in organization and activity, have nervous centres among which a considerable heterogeneity is produced by the greater size of some than of others. And besides a local integration of paired ganglia into single bi-lobed ganglia, there is an advance in general integration, shown by a clustering of the more important ganglia about the head. The Cephalopods, and especially the dibranchiate division of them, in which the molluscous type reaches its highest, show us, carried still further, that integration of the nervous system due to simple growth, joined with that integration due to concentration and coalescence of independent centres; and they also show us the differentiations involved by their changes of size, form, and distribution.

A delicate cord running from end to end of the body, and giving off lateral fibres in pairs, constitutes the nervous system in the lower *Annulosa*. When from limbless Annelids we pass to the Articulate types, composed of segments bearing limbs, we find the nervous system formed of a series of centres, each sending fibres to the different organs of its own segment, and all of them united by a thick cord of fibres with a fused cluster of similar centres in the head. In the higher *Articulata* there is an increased relative size of the nervous centres as compared with their connecting structures; an actual approach of the chief nervous centres to one another, both longitudinally and laterally; and a final coalescence of them. This integration disclosed by comparisons of lower and higher types, may also be observed in progress during the development of the individual insect or the individual crustacean. And along with advancing growth, consolidation, and combination of nervous structures, there may be traced an increasing unlikeness, both among the central masses themselves, among their connecting cords, and among their divergent fibres.

Such traits of evolution are exhibited under another form in the vertebrate sub-kingdom. Its lowest known member, the *Amphioxus*, has a simple cranio-spinal axis, the anterior extremity of which is not made appreciably different from the rest by development of distinct cerebral ganglia, and which gives off lateral nerves that have but minor dissimilarities. The cyclostome Fishes, possessed of cerebral ganglia that are tolerably manifest, lead us to the ordinary fishes, in which these ganglia, individually much larger, form a cluster of masses, or rudimentary brain. Here, however, though in contact, they preserve a serial arrangement: their aggregation is little more than that of close linear succession. But in the highest fishes certain of them which have greatly increased, overlap the others; and tend so to form a more compact, as well as a larger, aggregate. Superior Reptiles and Birds display this relative increase of certain of the clustered ganglia, and consequent obscuration of the rest, in a greater degree. It is carried still further in the inferior Mammals. From them upwards, the leading change of nervous structure is an augmentation of the two largest pairs of these aggregated nervous centres. In Man one pair has become so enormous that the others are most of them hidden by it, and nearly merged in it. Along with this direct integration there goes on the indirect integration constituted by more intimate and multiplied connections. These are both longitudinal and transverse. While in the *Amphioxus*, the cranio-spinal axis contains but a small proportion of the nerve-fibres which, running longitudinally, serve to unite its different parts; in a superior vertebrate animal, such uniting nerve-fibres are among the chief components of the cranio-spinal axis. And, similarly, while the lateral halves of the cerebrum are but slightly connected in Birds, and have connections that are relatively deficient in the inferior Mammals, they become, in the highest Mammals, joined together by a thick mass formed of innumerable fibres. Meanwhile there have been arising differentiations no less conspicuous. Beyond that general one due to development of the anterior end of the cranio-spinal axis into cerebral ganglia; and the further one of like nature which results from the relatively-enormous growth of some of these; other differentiations have been constituted by the local unlikenesses of structure simultaneously established. As they enlarge, the greater ganglia are rendered externally dissimilar from the rest by the formation of folds or convolutions; and their internal parts severally acquire distinctive characters. The same thing holds of the peripheral nervous system. Pairs of nerves that were originally almost uniform, are rendered multiform by the much greater growth of some than of others, and by the inner differences that accompany these outer differences.

This cursory survey of the nervous system under the various forms it presents throughout the animal kingdom, suffices to show how its evolution conforms to the laws of evolution in general. We are also shown by it what here more immediately concerns us—that while the rudimentary nervous system, consisting of a few threads and minute centres, is very much scattered, its increase of relative size and increase of complexity, go hand in hand with increased concentration and increased multiplicity and variety of connections. Carrying with us this general conception, let us now study its structure more closely: considering, at first, not any particular forms of it but its universal form.

§ 9. The nervous system is composed of two tissues, which both differ considerably from those composing the rest of the organism. They are usually distinguished from one another by their colours as grey and white, and by their minute structures as vesicular and fibrous. Chemical analyses have not at present thrown more than a flickering light on the constitution of nerve-matter in general, or on the constitution of one kind of nerve-matter as contrasted with the other. All that can be asserted with safety is, that each kind contains phosphatic fats and protein-substances; but that these components are both differently distributed and in different states in the two tissues. Let us see what we are told about them by the microscope, aided by chemical re-agents.

Where their evolution can be traced, the vesicles or corpuscles of the grey tissue appear to take their rise out of a nitrogenous protoplasm, full of granules and containing nuclei. Round these nuclei the protoplasm aggregates into spheroidal masses, which, becoming severally inclosed in delicate membranes (in many cases inferred rather than seen) are so made into nerve-cells. The protein-substance, thus forming alike the chief contents of the nerve-cells and the chief part of their matrix, is, though coagulated, soft. The granules imbedded in it, both within and without the cells, consist of fatty matter. And on comparing together nerve-cells in different stages, there are seen differences in the colours of the granules, indicating a progressive metamorphosis. To complete a general idea of the grey tissue, it must be added that the more developed of these nucleated cells, or nerve-corpuscles, give off processes, usually branched, that vary in number and degree of ramification; that among the corpuscles and their branches are distributed the terminations of nerve-fibres; and that while in some nervous centres it is common for these fibres to run directly into the cells or to be continuous with certain of the processes, in other nervous centres the connections between fibres and cells are rarely if ever direct, but where they exist, are made through the remote sub-divisions of branches given off by both.

When we pass to the white or fibrous tissue, we meet with matters that at first sight appear as distinct from the others in nature as in mode of arrangement. The fibres prove to be minute tubes. Within the extremely delicate membrane of which each tube is formed, there is a medullary substance or pulp, which is viscid like oil, has a pearly lustre, and consists of albuminous and fatty substances. But unlike as the contents of the nerve-tubes and the nerve-cells thus appear to be, a careful scrutiny discloses between them an essential kinship. For imbedded in the pulp which fills the tube or sheath, there lies a delicate fibre, or "axis-cylinder," which is composed of a protein-substance. Though chemically similar to the protein-substance contained in the cells of the vesicles, this is physically different; since, besides being comparatively firm or solid, it is uniform and continuous, instead of having its continuity broken by fat granules. That this central thread of protein-substance is the essential nerve, to which the sheath of medullary matter with its surrounding membranous sheath are but accessories, there are several proofs. One is that in the lower animals, as well as in the embryos of the higher, no medullary sheaths exist: the nerve consists of the axis-cylinder and its protecting membrane, without any pulp lying between them. Another proof is that at the peripheral terminations of nerves, even in superior animals, the medullary sheath commonly, if not always, stops short; while the central thread, covered by the outermost membrane, continues further, and ends in delicate ramifications not inclosed in distinguishable sheaths. And a further proof is that where a nerve-fibre unites with a nerve-cell, the medullary sheath ceases before arriving at the place of union; while the axis-cylinder joins the contents of the cell, and its protecting membrane becomes continuous with the cell-wall, where this exists. Hence concluding, as we are warranted in doing, that the axis-cylinder is its essential part, we see that the matter of nerve-fibre has much in common with the matter of nerve-vesicle: the differences between them appearing to be mainly that, in the nerve-vesicle, the protein-substance contains more water, is mingled with fat-granules, and forms part of an obviously unstable mass; whereas in the nerve-tube the protein-substance is denser, and is distinctly marked off from the fatty compounds that surround it: so presenting an arrangement that is relatively stable.

What is the meaning of this difference? Before seeking an answer we must remember that compound substances undergo two fundamentally different kinds of metamorphosis—one in which the components are some or all of them dissociated and distributed through surrounding space, either apart or in new combinations; and one in which the components, instead of being dissociated, are merely re-arranged, so as to alter the perceptible properties of the mass without destroying its physical continuity. The first we call decomposition; the second isomeric transformation. These forms of change are further distinguished in this, that the one is usually accompanied by a great dissipation of motion, whereas the motion given out or taken up along with the other is relatively insignificant. There is yet a third contrast. After decomposition the separated components cannot be readily made to resume their previous relations: often it is impossible to combine them again; and in most other cases it is difficult to do this. But in many instances of isomeric transformation, resumption of the original form may be produced by a very moderate change of conditions.

Now the two kinds of molecular change thus strongly contrasted, are the two kinds of molecular change which we have reason to suspect are undergone by the two forms of nervous matter. While the protein-substance mingled with fat-granules in the vesicles, is habitually decomposed; the protein-substance forming the axes of the nerve-fibres is habitually changed from one of its isomeric states to another. Such, at least, is the assumption here made, in conformity with the conclusion drawn in the *Principles of Biology* (§ 302); where it was argued that the propagation of molecular disturbances from one place in an organism to another, tends so to modify the mingled colloidal substances as to produce, between the two places, a form of colloid that undergoes isomeric transformation when disturbed, and communicates the disturbance in undergoing the transformation; and where it was argued that this easily-transformable colloid, having had such a change set up at one end of it and passed on to the other, giving out in the process some molecular motion and consequently falling in temperature, immediately re-absorbs from the adjacent tissues permeated by blood, an amount of molecular motion equal to that which was lost: thereupon resuming its previous isomeric state, and its fitness for again propagating a wave of transformation.

Much as there is here of hypothesis, the indirect evidence makes it probable that if this is not the true interpretation, the true interpretation is analogous to it. That the matter contained in the vesicles is the seat of destructive molecular changes, with accompanying disengagement of motion, while the matter contained in the tubes is the seat of changes which, of whatever special nature, do not involve much destructive decomposition and disengagement of motion, are beliefs for which we have several warrants;—among others, the following. The grey tissue contains far more water than the white tissue: the proportion of solids to water being about 12 per cent. in the grey tissue, while in the white tissue it is some 25 per cent. Now abundance of water facilitates molecular change, and habitually characterizes parts in which the rate of molecular change is high. Hence the implication is that the grey matter undergoes metamorphosis with much greater rapidity than the white. Stronger evidence is afforded by the fact that the grey or vesicular substance has a vascularity immensely exceeding that of the white or fibrous substance. On comparing the net-works of blood vessels that permeate the two, the difference is conspicuous; and it is much greater than at first appears. An estimate based on measurements, proves that a given bulk of the one contains about five times as many capillaries as an equal bulk of the other.* Now since these minute canals that bring and take

* The drawing on which this estimate is based, is contained in the *Manual of Human Histology*, by A. Kölliker: translated and edited by George Busk, F. R. S., and Thomas Huxley, F. R. S. The estimate is easily made. A number of equi-distant parallel lines being drawn transversely through the two net-works, the number of places at which one of these lines crosses blood-vessels within a given length (say an inch) is counted, and the like being done with an equal length of each of the other parallel lines traversing the same net-work, there is obtained, by taking an average, the number of vessels usually met with in a specified distance. The like process is then gone through with lines of the same length traversing the other net-work. These averages do not, however, truly express the comparative numbers of such intersections in the two net-works; since the meshes of the one are unlike those of the other in

away materials, must be numerous in proportion as composition and decomposition are quick; we may infer a great difference between the rates of destructive change in the two tissues. Another contrast supports this conclusion no less strongly. The unstable granular protoplasm contained in the corpuscles, is shielded from adjacent disturbing forces by a membrane which, even where thickest, is so delicate that its existence can be demonstrated only by the help of re-agents; and which in many corpuscles cannot be made visible at all. Hence between the matter contained in these corpuscles, or vesicles, and the streams of blood that run among them so abundantly, are interposed little else than the delicate walls of the capillary blood-vessels; and thus the disturbing substances brought by each capillary, can pass with the least possible hindrance into the unstably-arranged contents of the neighbouring vesicles. Quite otherwise is it with the relations of the blood to the contents of nerve-tubes. The wall of each nerve-tube is thick enough to make it easily demonstrated; and between it and the central thread of essential matter, comes the coat of nerve-medulla. Through these barriers the disturbing agents, carried among the nerve-tubes by sparingly-distributed capillaries, cannot readily pass; and the essential nerve-thread is prevented from having molecular changes set up in it at places between its two extremes. This protection suffices so long as the disturbing agents remain normal in their amounts; but when they become excessive, as they do if the blood-vessels become congested, local changes in the nerve-threads are caused: whence one kind of neuralgia. It should be added that by

shape. Hence it is needful to draw an equal number of parallel longitudinal lines; and to repeat with them this process of averaging. By taking the means between the resulting numbers and the previous numbers, we get a correct representation of the relative frequencies with which the vessels occur in space of one dimension. To ascertain their relative frequencies in space of three dimensions, or in solid tissue, it is of course needful simply to cube the two numbers so arrived at.

this sheathing of nerve-medulla, the essential nerve-threads, besides being shielded against disturbances from neighbouring currents of blood, are shielded against disturbances from nerve-threads in the same bundle. Were "axis-cylinders" lying in lateral contact not thus coated, a molecular change propagated through one would set up molecular changes in its neighbours; as, in fact, it does in an early stage of ataxy, characterized by loss of the medullary sheaths. Hence, too, the explanation of that normal absence of medullary sheaths which sundry nervous structures show us. For among the *Invertebrata*, in which this normal absence occurs, the fibres contained in the same bundle have nothing like those many and varied distinctions which they have in the higher animals: they have termini of which the structures and functions are much less differentiated. Similarly with those bundles of grey or non-medullated fibres, contained in the sympathetic system of vertebrate animals; for these bundles, serving to establish relations among the viscera, each of which is much less divided into parts that act independently, there needs no such perfect insulation of the nerve-fibres. And the like holds even in certain portions of the peripheral cerebro-spinal system; as the olfactory expansion, which consists of an extensive plexus of non-medullated fibres, and which has the peculiarity that different parts of its area are not acted upon separately.

The evidences, direct and indirect, thus justify us in concluding that the nervous system consists of one kind of matter under different forms and conditions. In the grey tissue this matter exists in masses containing corpuscles, which are soft and have granules dispersed through them, and which, besides being thus unstably composed, are placed so as to be liable to disturbance in the greatest possible degree. In the white tissue this matter is collected together in extremely slender threads, that are denser, that are uniform in texture, and that are shielded in an unusual manner from disturbing forces, except at their two extremities. And the implication on which we henceforth proceed is, that the masses, unstably constituted and conditioned, are seats of destructive molecular changes, and disengagement of motion; while the stably constituted and conditioned threads, are the seats of molecular changes that are not destructive, and are probably isomeric.

§ 10. Nerve-tubes with their contained protein-threads, and nerve-cells with their contained and surrounding masses of changing protein-substance, are the histologic elements of which the nervous system is built up; and we have now to ask in what way they are put together. We will begin with the peripheral terminations of the nerve-tubes; or rather, with those of them which lie on the outer surface.

Suppose the skin, including those introverted portions of it which form the receptive areas of the special senses, to be marked all over in such a way as to form a net-work. Suppose the meshes of this net-work to vary extremely in their sizes; so that while in some places they are as large as those of a fishing-net, they are in other places not large enough to admit the point of a needle. Or, to speak specifically, suppose that on the middle of the back the meshes are some $2\frac{1}{2}$ inches in diameter, and that being equally large over the middles of the fore-arms, and the middles of the thighs, they diminish to 2 inches and less over the neck and breast, to $1\frac{1}{2}$ inches at the extremities of the legs, to $1\frac{1}{4}$ inches on the backs of the hands, to less than an inch on the forehead, to less than half-an-inch over the cheeks and over the palms of the hands, to a quarter of an inch and less over the fingers, to a twelfth of an inch at the inner tips of the fingers, and at the tip of the tongue to one twenty-fourth of an inch in diameter; and suppose, further, that over the back of that dermal sac which forms the eye, these meshes are so small that a microscope is required to distinguish them. Having imagined such a net-work of which the meshes, irregularly polygonal in their outlines, are thus wide over parts of the surface that have but little variety of converse with the external world, and become smaller in proportion as the surfaces have multiplied and variable contacts with things; we shall have gained an approximate idea of the relations among the separate local areas in which there arise independent nerves. To complete the conception, however, something else must be supposed. The large meshes we must represent as marked out by very broad lines—say a quarter of an inch broad where the meshes are largest. We must imagine them narrowing as the meshes become smaller; until, when we come to the meshes over the surface of the retina, the dividing lines have dwindled to the thickness of a gossamer thread. And now let us conceive that within each of these areas, large or small as it may happen, there exists a plexus of fibres, formed of the essential nerve substance, that are continuous with one another, but have no connection with the fibres occupying adjacent areas. Not, indeed, that we must conceive any sharp limitation of the space occupied by each plexus. We must assume that the line separating two areas, here very broad and here very narrow, covers a space into which fibres from both the areas run, without joining one another. Hence the area belonging to each independent plexus, is the internal area of the mesh, plus the space occupied by its circumscribing broad or narrow line; and the breadth of the line represents the extent to which adjacent areas overlap. Such, then, are the peripheral expansions of those nerves which are liable to be acted on by external forces. Here each monopolizes a relatively-great tract of the surface, and here an extremely minute one. Each is an independent agent—each is capable of having a change set up in it without changes being set up in its neighbours. The skin is, as it were, occupied all over with separate feelers, that are here widely scattered, here clustered, and here crowded together as closely as maintenance of their individualities will allow.

From the nerve-plexus occupying one of these areas, there takes its rise the central fibre, or axis-cylinder, of a nerve-tube. Coated with its medulla and inclosing sheath, it takes its way from the surface inwards, and, proceeding without any branch or junction, eventually reaches a mass of grey matter with imbedded vesicles—a nerve-centre or ganglion. Into the substance of this the essential nerve-thread runs, becoming divested of its medullary sheath; and where the structure is least involved, the essential nerve-fibre frequently if not always ends in a nerve-vesicle. In such simple, and what we may call typical, centres, there branches out from some other part of the nerve-vesicle, another nerve-fibre which, similarly inclosed in its double sheath, pursues an outward course, ordinarily along the same general route as the first, until, reaching the same part of the body, it buries itself in a bundle of muscular fibres amid which its ramifications end. Thus we have as the elements of what is called a nervous arc—1, a peripheral expansion, placed where it is liable to be disturbed by an external agent, and so formed as to be most easily disturbed; 2, a connected fibre capable of being readily affected by disturbances at this outer end, but shielded from disturbances elsewhere; 3, at, or near, the inner end of this fibre, a corpuscle of unstably-arranged substance, apt to give out much molecular motion when disturbed; 4, a second fibre diverging from the corpuscle, or its neighbourhood, and subject to disturbance from the molecular motion disengaged near its origin, but protected from other influences; 5, at the remote extremity of this second fibre, a subdivided termination amid a substance that contracts greatly when disturbed, and which, in contracting, moves the part of the body in which the first fibre took its rise. Fig. 1 is a diagram representing these elements of a nervous arc: A being the first, or, as it is called, afferent nerve, with its peripheral expansion *a*; B being the nerve-corpuscle or ganglion-cell; and C the second, or efferent, nerve, with its termination *c*.

Fig. 1.

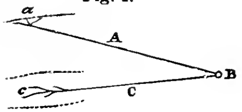
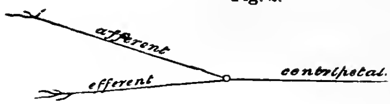


Fig. 2.



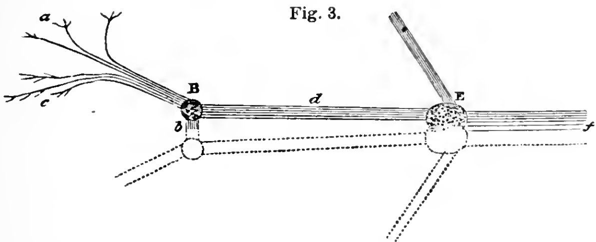
This arrangement of parts is perpetually repeated throughout the nervous system; and if we generalize the conception somewhat by supposing that the commencement *a* is not necessarily external, but may be on an inner surface, or within an organ, while the termination *c* is not necessarily in a muscle but may be in a gland; we shall have a conception that is, in a certain sense, universally applicable. I say in a certain sense, because, until another element is added, the conception is incomplete. These coupled nerves, with the ganglion-cell acting as a direct or indirect link between them, recurring everywhere in substantially the same relations, appear to form a compound structure out of which the nervous system is built—its unit of composition. But this is not so. By multiplication of such arcs we may get a multitude of separate nervous agencies, but not a nervous system. To produce a nervous system there needs an element connecting each such nervous arc with the rest—there needs a third fibre running from the ganglion-cell, or its neighbourhood, to some place where other communicating fibres come; and where, by direct or indirect junctions, actual or approximate, the primary couples of nerves may be brought into relation. That is, there requires what we may call a *centripetal* nerve.* In

* The words *centripetal* and *centrifugal* are occasionally used in nerve-physiology as the equivalents of afferent and efferent. But as afferent and efferent are by far the most generally adopted, and are also the most descriptive, it seems to me that the word *centripetal* may with advantage have this more special meaning given to it; and *centrifugal* the correlative meaning

Fig. 2 is shown, diagrammatically, the relation in which this stands to the others. A centripetal nerve being added, there results what we may fairly regard as the unit of composition of the nervous system. We shall have presently to recognize certain fibres which this conception does not include. But they are not essential; for a nervous system is possible without them. Let us, then, taking this as our unit of composition, consider the general method after which a nervous system is constructed.

§ 11. The fibres represented in the above diagrams, do not ordinarily pursue their respective courses by themselves: they proceed in company, as shown in Fig. 3. The afferent nerves arising at *a*, in separate but adjacent areas on the skin, or in other organs recipient of external impressions, converge; and, while maintaining their separate individualities, become united into a bundle inclosed in a sheath.

Fig. 3.



Other sheathed bundles of fibres from other clustered areas in the same region, presently join them, and run along with them in a compound bundle, until they eventually reach the mass of imbedded nerve-vesicles constituting a ganglion or nervous centre B. Similarly the efferent nerves which have their roots in this ganglion, issue from it as a bundle, which, commonly inclosed in the same general sheath as the afferent nerves, goes back to the part of the body whence these arose; and secondary bundles of these efferent nerves, diverging and re-diverging from one another as they enter this part, as at *c*, finally become lost in its various muscles.

In like manner the centripetal fibres *d*, originating in this ganglion, take their common course, joined perhaps by other fibres originating elsewhere, towards a ganglion E, that is larger and has more numerous connections. Of course the clustered lines and spotted circles in Fig. 3, are entirely diagrammatic—give no idea of the separate nerves and bundles and ganglia as they actually exist; but merely of the relations in which they stand to one another. It should be added that the more central ganglion, to which converge other bundles of centripetal nerves (together with some afferent nerves that pass through inferior ganglia without stopping) may itself be subordinate to a still superior, or still more central, ganglion. To this it gives off what may be called superior centripetal nerves; and other nerves of the same or of a lower order being brought to it, this highest ganglion becomes a place where there are established communications among all the subordinate and sub-subordinate ganglia, with their afferent and efferent fibres.

One further kind of connection exists. The immense majority of animals, have their parts symmetrically arranged —sometimes radially but more frequently bi-laterally. For the corresponding parts there are habitually corresponding ganglia; and the connections that remain to be named are those between these corresponding ganglia, or ganglia which belong to the same grade. Such connections consist of what are called commissural fibres. They are indicated at *b*, where they transversely join the structure shown in detail, with the answering structure belonging to the other side of the body. The word commissural is, indeed, sometimes used in a wider sense: including fibres that unite ganglia of different grades. But since the great majority of the fibres called commissural are those which join duplicate ganglia, or else ganglia that occupy like relations in the hierarchy, it will, I think, conduce to clearness to restrict its application to these: leaving the word centripetal for fibres which connect ganglia of lower orders with those of higher orders.

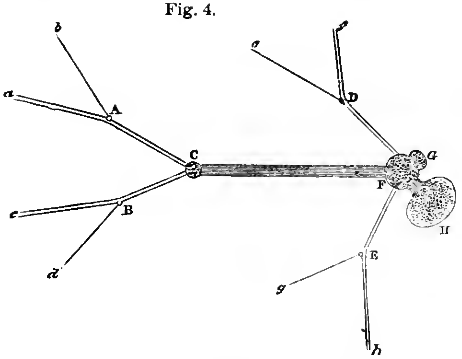
The commissures thus bringing into relation the members of each pair of centres, inferior or superior, and so linking the two halves of the nervous system, complete the nervous communications throughout the organism.

This description, purposely generalized with a view of exhibiting the principles of nervous organization, apart from any particular type, may be fitly supplemented by the description of a special structure that illustrates them. Each sucker on any arm of a cuttle-fish, has a ganglion seated beneath it. To this descend the afferent nerves that are affected by touching the sucker; and from it ascend the efferent nerves distributed to the muscular fibres of the sucker. These form a local nervous system that is experimentally proved to have a certain completeness in itself. But now from the ganglion underneath each sucker, fibres run along the arm, in company with fibres from all similar ganglia in the arm; and this bundle of centripetal fibres eventually reaches a ganglion at the base of the arm. Each arm, similarly constructed, thus has a chief nervous centre in which the fibres from all its minor nervous centres are brought into communication. Further, all round the ring formed by the united base of the arms, there runs an annular commissure connecting these superior ganglia. And then from each of them is given off a bundle of fibres that proceed centripetally to a still higher centre—the cephalic ganglion; where, consequently, nerves from all the arms are brought into direct communication with one another, and also into communication with nerves arriving from ganglia in other parts of the body. Omitting details and qualifications, not essential to such a conception as concerns us here, we thus see that in nervous structure there is a centralization and re-centralization, that is carried far in proportion as the organization is high.

§ 12. We may be sure that along with a principle of arrangement among connecting structures, there goes some principle of composition in the centres that are connected; which are not simply places for the meeting of fibres, but places in which there exist agents liable to be acted on by the in-coming fibres and capable of acting on the out-going fibres. Respecting the principle of composition, our reasonings must be mainly hypothetical; but they will, I think, prove of some worth, by leading us to conclusions that harmonize with observation, so far as this carries us.

In ascending from the lowest to the highest types of the nervous system, we see that the distribution and combination of nerve-fibres are so modified, as to make possible an increasing multiplicity, variety, and complexity of relations among different parts of the organism. What kind of modification does this necessitate at places where the nerve-fibres are put in communication? Without assuming that two fibres which bring two parts of the organism into relation, are always united at their central extremities by an intermediate nerve-corpuscle, it may be safely assumed that continuity between their central extremities must be effected either by a nerve-corpuscle or by some less-defined portion of grey substance; and it is clear that in proportion to the number of different connections to be established among the nerves coming to any ganglion, must be the number of the more or less independent portions of grey substance required to establish them. Let us consider the implications. Suppose that *a* and *b*, Fig. 4, are two points in the organism. To join the nerves proceeding from them, there needs only the single ganglion-cell A. Similarly, to bring into nervous relation the points *c* and *d*, the single ganglion-cell B suffices. So long as A and B remain unconnected, these two simple relations are the only possible ones among the points *a*, *b*, *c*, *d*. But now assume that from A and B there run fibres to the centre C—not a single fibre from each, but two fibres, one of which in each case proceeds from *a* or *b*, and from *c* or *d*. This being so, there may be formed at C, eleven simple and compound relations: these four points can be arranged into six groups of two, *a b*, *a c*, *a d*, *b c*, *b d*, *c d;* into four groups of three, *b a c*, *b a d*, *a c d*, *c b d;* and into one group of four, *a b c d*. Hence, supposing the centre C to be made up of the independent cells, or portions of grey substance, severally serving to link the members of a group into a separate combination, there must be at least eleven such. If, again, from this centre C, we assume that there run adequately numerous fibres to the higher centre F, and that this is also duly connected through the centres D and E, with the points *e*, *f*, *g*, *h:* then the possible number of groups, simple and compound, that may be formed at F, will amount to 247; and to unite the members of each group so that it may be independent of the rest, there must be at least 247 connect-

Fig. 4.



ing links at the centre F. Without pursuing the calculation, it will be manifest that as these points in the organism increase in number, and as the clusters of them that are to be brought into relation become larger and more various, the central elements through which their relations are established must grow multitudinous. An inadequate conception, however, is thus reached; for we have considered only the requisites for forming among these points, the greatest *number* of different groups, simple and compound; ignoring the different *orders* in which the members of each group may be combined. Two things can be arranged in succession in only 2 different ways; three things can be arranged in 6 different ways; four things in 24 ways; five things in 120 ways; six things in 720 ways; seven things in 5,040 ways; and so on in a progression increasing with enormous rapidity. Assuming, then, that at the centre F, certain points, *a*, *b*, *c*, *d*, *e*, are to be combined, not in this succession only, but in all possible successions, there will require 120 different links of connection for this one group of five points only. These links, whether separate vesicles or less-differentiated portions of grey matter, must occupy a considerable space; and supposing they are aggregated near those pre-existing cells or links which they have to re-combine in various orders, there may result a protuberance from the centre F, as shown at G. If we suppose that instead of a group of five, a group of six is to have its members thus variously combined; or if instead of one group to be so dealt with, there are many; this lateral outgrowth may become relatively very large. And since its vesicles, or portions of grey matter, will be much more bulky than the fibres running from them to the members of groups which they combine, there may be expected to arise, as at H, a lateral centre attached to the original centre, F, by a pedicle of fibres.

Of course these diagrams and numbers are intended to convey nothing but a general idea of the principle of composition of nerve centres—not to represent any actual composition. It would be an absurd assumption that among a number of points in the body, there have to be formed as many unlike groups as are theoretically possible; and it is not to be supposed that the members of any group need ever to be combined in as many different orders as they might be combined. But while, on the one hand, the above description greatly over-states the accumulation of nerve-vesicles, or their equivalents, implied by such correlations as are actually required among a given number of points in the organism; it immensely under-states the number of points to be so correlated, as well as the number, and variety, and complexity, of the groups into which they are to be combined. The places from which afferent nerves proceed, as well as the places to which efferent nerves proceed, are multitudinous. Very large groups of such places have their members put in simultaneous communication. The different groups so formed are innumerable. And extremely varied relations of succession are established among members of the same group; as well as among different groups. Hence we are safe in asserting that along with an increasing multiplicity and heterogeneity of nervous connections, there must go increasing massiveness of the nervous centres, or accumulations of vesicular matter.

One further corollary deserves noting. Each vesicle, or each portion of grey matter that establishes a continuity between the central termini of fibres, is not merely a connecting link: it is also a reservoir of molecular motion, which it gives out when disturbed. Hence, if the composition of nerve-centres is determined as above indicated, it follows that in proportion to the number, extensiveness, and complexity, of the relations, simultaneous and successive, that are formed among different parts of the organism, will be the quantity of molecular motion which the nerve-centres are capable of disengaging.

§ 13. As a datum for Psychology of the most general kind, the foregoing description of nervous structure might suffice. But having to deal chiefly with that more special Psychology distinguished as human, it will be proper to add some account of the human nervous system. A few facts of moment respecting its peripheral parts, may be set down before we study its central parts.

At the surface of the body, where the extremities of nerve-fibres are so placed as to be most easily disturbed, we generally find what may be called multipliers of disturbances. Sundry appliances which appear to have nothing in common, have the common function of concentrating, on the ends of nerves, the actions of external agents. That this is the effect produced by the lenses of the eyes, is a familiar fact. It is a less familiar fact that certain otolites and minute rods or fibres, immersed in a liquid contained in the internal ear, serve to transform the less sensible vibrations communicated to this liquid, into the more sensible vibrations of solid masses, and to bring these directly to bear on the nerve-terminations. So, too, is it over the integument; or, at any rate, over the parts of it subject to many and varied contacts. Though men have not, like many inferior Mammals, the well-developed tactual multipliers called *vibrissæ* (known in a cat as "whiskers"), each of which is a lever that intensifies a slight touch at the outer end into a strong pressure of the imbedded end upon an adjacent nerve-fibre; yet every one of the short hairs on a man's skin acts in the same way. And then, in addition to these, there are, at places where the contacts with objects are perpetual, and where hairs do not grow, certain multipliers below the surface—small dense bodies named *corpuscula tactûs*, round each of which a nerve-fibre ramifies, and each of which, when moved by the touch of a foreign body, gives to its attached nerve-fibre a greater pressure than this would receive were the surrounding substance homogeneous: a fact which will be understood on remembering the effect of pressure on the skin when some small hard body, as a thorn, is imbedded in it.

So much for the instruments that are external to the peripheral expansions of the nerves, and serve to exaggerate the effects of incident forces. We may now contemplate these peripheral expansions themselves, as being adapted to receive these exaggerated incident forces. In the first place, the ultimate nerve-fibrillæ, ramifying where they are most exposed to disturbances, consist of nerve-protoplasm unprotected by medullary sheaths and not even covered by membranous sheaths. In fact, they appear to consist of matter like that contained in nerve-vesicles, but without the fat-granules; and may be regarded as, like it, more unstable than the matter composing the central fibres of the fully-differentiated nerve-tubes. To this general character of the nerve-terminations, have to be added the more special characters of the terminations exposed to special forces. The delicate pale fibres which form a layer on the surface of the retina, are not directly affected by the rays of light concentrated upon them; but these rays, passing through them, fall on a layer of closely packed, but quite separate, little bodies which are the true sensitive structures; and then the minute nerve-fibrillæ that run from these to the stratum of retinal nerve-fibres, pass on their way into a layer of nerve-vesicles, with which we may presume they have connections. That is to say, this peripheral expansion of the nerve on which visual images fall, contains numerous small portions of the highly-unstable nerve-matter, ready to change, and ready to give out molecular motion in changing. It is thus, too, with those terminal ramifications of the auditory nerve, on which sonorous vibrations are concentrated. And there is an analogous peculiarity in the immensely-expanded extremity of the olfactory nerve. Here, over a large tract covered by mucous membrane, is a thick plexus of the grey unsheathed fibres; and among them are distributed both nerve-vesicles and granular grey substance, such as that out of which the vesicles arise in the nervous centres.

The significance of these structural peculiarities we shall see hereafter. For the present we need only note the distribution of them. Over the skin, which is conversant with forces of a relatively-considerable intensity—mechanical impacts, pressures, tensions,—we do not find that the nerve-terminations contain deposits of the peculiarly unstable nerve-substance. But we find such deposits where the incident forces are extremely feeble, or fall on excessively small areas, or both. The quantity of matter which, floating as faint odour through the air, reaches the end of the olfactory nerve, is infinitesimal. Such luminiferous undulations as are allowed, during a momentary glance, to fall on one of the minute areas of the retina, are equivalent to a mechanical force inappreciable by our measures, if not inexpressible by our figures. Similarly with those atmospheric waves which, produced by the church-bell a mile away, and weakening as they spread in all directions, are conveyed to the minute otolites and rods of the inner ear, to be by them impressed on the auditory nerves. And in these places it is that we find peripheral deposits of the specially-unstable nerve-substance.

§ 14. Arising from these variously-specialized peripheral structures, the afferent nerves, collected into their bundles and compound bundles, run inwards to the spinal cord; out of which issue the corresponding bundles of efferent nerves. In one sense the spinal cord may be regarded as a continuous nervous centre; and, in another sense, as a series of partially-independent nervous centres. Each pair of trunk nerves with its segment of the spinal cord, has a certain degree of individuality; and those segments into which enter the pairs of massive nerves from the limbs, have individualities considerably pronounced; since it is experimentally proved that when severed from the rest they are not incapacitated. The tract of grey matter in the spinal cord to which the afferent nerves of a limb come, and from which the efferent nerves issue, is practically the ganglionic centre of that limb, having very much of automatic independence; and being joined by commissural fibres to a like centre belonging to the fellow limb, it forms with this an automatic pair. So that, remembering how the entire cranio-spinal axis is originally one and continuous, and that its anterior part has been differentiated and developed into quite distinct centres we may say that its posterior part, the spinal cord, has also been so differentiated, though to a much smaller extent. To this conception two additions must be made. Beyond the internal tracts of grey or vesicular matter, and the bundles of nerve-fibres that enter into and issue from them laterally; and beyond the transverse commissural fibres which connect the corresponding lateral portions of grey matter or partially-differentiated pairs of nervous centres; there are longitudinal commissural fibres, joining these successive pairs of nervous centres with one another, and serving to integrate the series of pairs in the same way that the members of each pair are integrated. And then, along with these fibres that unite nervous centres of the same order, there are what we found it desirable to distinguish as centripetal fibres, running from the relatively-inferior nervous centres to the relatively-superior ones; with centrifugal fibres running back.

Of these relatively-superior nervous centres, we have first to notice the *medulla oblongata;* including those parts of the *pons Varolii* which are woven into it, and similarly arise out of the fourth ventricle. This is the enlarged termination of the spinal cord, lying within the skull. Distinguished as it is from lower parts of the spinal cord by its greater massiveness, it is much more distinguished by the multiplicity and variety of its peripheral connections. While the successive segments of the spinal cord proper, have pairs of afferent and efferent nerves which are limited in their distributions to particular regions of the body; and while even such an entire group of these segments as occupy the lumbar region, have relations only with the legs and the lower part of the body; the *medulla oblongata*, by the intermediation of centripetal fibres, is brought into relation not only with the lower part of the body and its limbs, but with the upper part of the body and its limbs; and not only with these, but also with sundry of the parts which we know as the organs of the special senses; and not only with these, but also with the more important viscera. The auditory nerves and the nerves of taste go directly into it, and though the optic nerves do not, yet from the centres to which they run there are fibres communicating with it; from its laterally-appended parts arise the nerves of the eye-muscles and the facial nerves; and the pneumogastric nerves, given off from its posterior part, put it in communication with the larynx, the lungs, the heart, the liver, and the stomach. Respecting its connections, direct and indirect, much remains to be ascertained; but what is known justifies the conclusion that the *medulla oblongata*, including the structures that are adnate, is a portion of the originally-uniform cerebro-spinal axis, which has been differentiated into a centre of a higher order than those behind it, or those at the base of the mass in front of it—higher in the sense that it has become that portion of the axis in which centripetal fibres running from the posterior ganglia, and from some, if not all, of the anterior ganglia, called by some sensory, are brought into relation with one another—a centre through which these local centres are united into one system.

Passing over with a mere recognition the anterior ganglia just named, the exact relations of which are ill-understood, but some of which comparative morphology proves to be portions of the front end of the cerebro-spinal axis that have become differentiated into ganglia of the first order, receiving those special external stimuli to which the front end of the body is exposed; there remain only to be noticed the two great bi-lobed ganglia, which in Man form the chief mass of the brain—the cerebellum and the cerebrum. Physiologists and anatomists are agreed in regarding these as centres of a still higher order. Anatomical proof of their superiority, as being the seats of still higher centralization, is very incomplete; for the difficulty of tracing the courses of all the nerve-fibres that enter into and issue from them, has hitherto been insuperable. But their connections with the subjacent minor centres and with the *medulla oblongata*, are such as to make it certain that through the intermediation of these, they communicate with the whole peripheral nervous system; and are places in which centripetal fibres from centres of both the first and second orders, joined, possibly, with some simply afferent fibres, are brought into various relations: relations, however, that most likely differ in their natures from those established in inferior centres—differ, perhaps, as those supposed to be formed in the centre H, Fig. 4, differ from those formed in the centre F.

Among the facts of fundamental significance with which we are here concerned, one other may be named. This concerns the histological structures of nervous centres. In automatic ganglia, the direct union of nerve-fibres with nerve-cells is habitual. Throughout the spinal cord the "axis-cylinders" may not unfrequently be traced running into the vesicles. But in the higher nerve-centres direct connections are much less readily made out; and it is questionable whether in the highest they occur at all. In the grey substance of the cerebrum, the delicate nerve-fibres which, divested of medullary sheaths, run among the imbedded corpuscles, do not directly unite with them; or if it is too much to say that there are no such unions, we may say that they are rare. Such communications as exist are apparently between the branched terminations of the fibres and the ramified processes of the corpuscles. Thus at the one extreme, simple, clear, and complete connections are the rule; and at the other extreme, involved, vague, and incomplete connections.

§ 15. Some account must be given of certain remaining nervous structures, with which Psychology is indirectly concerned. Thus far we have dealt only with the fibres and centres that stand passively and actively related to the external world; but there are fibres and centres that stand related to those internal organs which make possible the continuance of relations to the external world.

The first to claim attention are the vaso-motor nerves. Bundles of these issue from the spinal cord, and, joined by bundles of nerves arising from the sympathetic system, accompany the main arteries: dividing and subdividing wherever these do, so as to supply fibres to all their branches down to the most minute. The vaso-motor nerves form, in fact, an additional series of efferent nerves. The nervous arc under its lowest form, consists of the afferent nerve with its peripheral extremity exposed to external actions, the ganglion-corpuscle to which its central extremity runs, and the efferent nerve thence issuing to end in some muscle. But as we have seen, the unit of composition of the developed nervous system, includes a centripetal fibre, running from the first or subordinate centre to a higher centre; and here we have to add, as an habitual element of this unit of composition in its complete form, a vaso-motor fibre, running to that part of the body in which the two ends of the nervous arc lie, and bringing the blood-vessels of that part into relation with the other parts of the apparatus.

The cerebro-spinal nervous system, besides having these direct communications with the muscular walls of the tubes which bring blood, both to itself and to the muscles it sends fibres to, is also put into relation with other parts on which it is equally, though less immediately, dependent—the viscera. These have, indeed, a nervous system of their own, possessing apparently a considerable degree of independence—the sympathetic system; and one all-important viscus, the heart, has a nervous system that is demonstrably independent. The morphological interpretation of the visceral nervous system is not settled; but whether it has a separate origin, or belongs to the periphery of the cerebro-spinal system, the undoubted fact is that the cerebro-spinal system, through the nerves running from it into the trunks of the sympathetic, communicates with all these vital organs; and that even the heart, complete as is its local nervous system, is, by the vagus or pneumogastric nerve, integrated with the cerebro-spinal system.

A more particular account of these and sundry structures of the same class is not necessary here. The general fact of significance for us, is, that the brain and spinal cord which through their afferent nerves are put in relation with the actions of the external world, and which through their efferent nerves are put in relation with the structures that react on the external world, are also put in relation with the organs immediately or remotely instrumental in supplying them with nutriment, and removing the effete matters resulting from their activities.

§ 16. In the foregoing description I have endeavoured to include all that Psychology needs. Many conspicuous traits of nervous structure which some will think ought to be set down, are really altogether irrelevant. That in the spinal cord the gray matter is placed internally, while in the cerebrum it forms an outside stratum, is a fact of moment in anatomy, but one which throws no light on the science of mind. Knowledge of the truth that the posterior roots of the spinal nerves are afferent, while the anterior are efferent, is all-important to the pathologist; but to the psychologist it is quite unimportant, since this arrangement might have been reversed without the principles of nervous structure being in the least changed; and it is with these principles only that the psychologist is concerned. The leading facts embodying these principles may be summed up thus:—

The three great sub-kingdoms of animals in which the nervous system becomes considerably evolved, show us that along with the relatively-increased massiveness distinguishing the higher types of the nervous system, there goes that other kind of integration implied by increase of structural combination. There is multiplication and enlargement of the parts that unite local nervous centres with general nervous centres. Very frequently there is an approach or clustering of nervous centres that were previously far apart. And there is both a relative and an absolute increase in those centres which have the most multiplied relations with local centres, and through them with all parts of the body.

The nervous system is made up of threads inclosed in sheaths, and corpuscles imbedded in protoplasm; of which the threads, united into bundles, constitute almost the whole of the peripheral parts, while the corpuscles with their matrix are found chiefly in the central parts. Having at its outer extremity a plexus of highly-unstable matter, a nerve-thread, consisting as we conclude of less unstable matter but matter isomerically transformed with ease, runs inwards, surrounded by substances that shield it from lateral disturbance. Eventually it reaches a mass of highly unstable matter, so conditioned as to undergo decomposition with the greatest facility; and from the place where this lies there run other like fibres to other masses of unstable matter, of the same kind, or of a different kind, or both—here to a portion of substance that contracts when disturbed, and here to a superior centre containing more of the easily-decomposed nerve-substance. These threads, afferent, efferent, and centripetal, with their connecting corpuscle or portion of grey matter, we regard as forming the unit of composition of the nervous system.

Such units are variously grouped and combined. Each local ganglion is a place where many afferent and many efferent nerves are connected by many portions of the unstable nerve-matter, capable of suddenly giving out much molecular motion. Each superior ganglion is a place where centripetal and centrifugal fibres from such local or inferior ganglia, are similarly connected by similar matter. And so with still higher ganglia in their relations to these. From which principle of combination it results that the possibilities of different compound relations increase as fast as the centralization progresses.

We saw, however, that this establishment of more numerous, more involved, and more varied relations among the parts of the organism, implies not simply this grouping of fibres and this arrangement of centres; but also a multiplication of the nerve-corpuscles, or portions of grey matter, occupying their centres. And we found it to follow that where the compound relations formed are among many points, or where the points are to be combined in many orders, or both, great accumulations of grey matter are needed: an important corollary being that the quantity of this matter capable of giving out much motion, increases in proportion as the combinations formed become large and heterogeneous.

Passing to the special nervous structure related to that special Psychology of chief importance to us, we saw that the spinal cord is a series of partly dependent, partly independent, double nerve-centres; each concerned with a particular portion of the trunk or a particular limb, to the skin, muscles, and vessels of which it sends nerves. The enlarged cephalic extremity of the spinal cord, the *medulla oblongata*, is a centre connected by centripetal fibres with these partially-differentiated inferior centres; and receiving, as it also does, directly or indirectly, nerves from the special sense-organs, the *medulla oblongata* is a centre where the local centres concerned with nearly all parts of the body, are brought into communication. We saw, lastly, that the two great bi-lobed masses overlying the *medulla oblongata* and the sensory ganglia, with which they are intimately connected, may be regarded as centres in which these compound connections are united into connections still more compound, still more various, and still more numerous.

One further fact which it remained for us to note, was that while the more important nervous structures are those which bring the parts that are acted upon by the outer world, into relation with the parts that react upon it, there are also nervous structures that bring all these into relation with the vital organs: so serving to unite the parts which expend, with the parts which accumulate and distribute.

CHAPTER III.

THE FUNCTIONS OF THE NERVOUS SYSTEM.

§ 17. When, at the outset, we inquired what are the manifestations with which the nervous system is associated, we necessarily, in drawing a conclusion, asserted in general terms the part performed by the nervous system. And though in the chapter just ended the sole aim has been to describe nerve-threads, nerve-cells, nerve-trunks, nerve-centres, and the ways in which they are put together; yet the ends subserved have unavoidably, from time to time, come into view. Structure and function are in our thoughts so intimately related, that it is scarcely possible to give a rational account of the one without some tacit reference to the other. Here, however, function is to be our special topic. Having seen how the nervous system is constructed, we have now to see how it works.

The proposition with which the first chapter ended was that nervous evolution varies partly as the quantity of motion generated in the organism, and partly as the complexity of this motion. Here the initial inquiry must be, how the nervous system serves as at once the agent by which motions are liberated and the agent by which motions are co-ordinated. Three things have to be explained:—1. What are the causes which on appropriate occasions determine the nervous system to set up motion? 2. By what process does it liberate the insensible motion locked up in certain tissues, and cause its transformation into sensible motion? 3. How does it adjust sensible motions into those combinations, simultaneous and successive, needful for efficient action on the external world? These questions cover the whole of its functions; or, at any rate, all those of its functions with which we are directly concerned. We have to interpret its passive function as a receiver of disturbances that set it going; its active function as a liberator of motion; and its active function as a distributor or apportioner of the motion liberated.

Probably it will be thought that there is here introduced a function distinct from those before named. It seems that the receiving of disturbances, or stimuli, can be included neither under the head of disengaging motions nor under the head of co-ordinating motions. But on reducing the facts to their lowest terms, and to those terms which Physiology proper can alone recognize, the difficulty disappears. For all nervous stimuli are motions, molar or molecular; and the function of co-ordinating motions comprehends not simply the combining and apportioning of the motions expended, but also the combining of the motions received, and the adjustment of the one set into harmony with the other. A moment's thought justifies this proposition. The stimuli to the nerves of touch are sensible motions of the imbedding tissue, caused either by the impacts of external moving bodies or by motions of the organism which bring it against external bodies, fixed and moving. The auditory nerve receives the motions conveyed to it from masses of matter that are vibrating. Those minute agents that terminate the nerves of the retina are acted on by luminiferous undulations—motions of the ethereal medium which produce motions among their molecules. So, too, the nerves excited by sapid and odorous substances, are, in fact, excited by the molecular movements these substances cause in their extremities by chemically changing them. Thus, speaking not figuratively but literally, an afferent fibre of whatever kind is a recipient of motion given to its molecules: either by molar motion, as when a blow is received; or by the motion of other molecules, as when there is contact with a chemically-active body; or by those ethereal molecular motions which constitute radiant heat and light.

It will be well to consider more fully this sub-division of nervous functions, and the reasons for here proceeding upon it.

§ 18. Physiology is an objective science; and is limited to such data as can be reached by observations made on sensible objects. It cannot, therefore, properly appropriate subjective data; or data wholly inaccessible to external observations. Without questioning the truth of the assumed correlation between the changes which, physically considered, are disturbances of nerves, and those which, psychically considered, are feelings; it may be safely affirmed that Physiology, which is an interpretation of the physical processes that go on in organisms, in terms known to physical science, ceases to be Physiology when it imports into its interpretations a psychical factor—a factor which no physical research whatever can disclose, or identify, or get the remotest glimpse of. The relations between nerve-actions and mental states form a distinct subject, to be dealt with presently. Here we are treating of nerve-actions on their physiological side, and must ignore their psychological side.

Doing this, we have no alternative but to formulate them in terms of motion. And having recognized the primary division to be that between the liberation of motions and the co-ordination of motions, we find that this last division must be sub-divided. It includes, first, the co-ordination of the motions received with one another; and, second, the co-ordination of the motions expended with the motions received, and with one another. Hence results a generalized idea of nervous functions, as divisible into *recipio-motor*, *libero-motor*, and *dirigo-motor*.

It must be admitted that in their higher forms, these functions are so entangled that a tripartite division of them is difficult, if not impossible. To the simplest types of nervous structure, the classification is easily applied: each afferent nerve is a *recipio-motor* agent; each ganglion is a *libero-motor* agent; each efferent nerve is a *dirigo-motor* agent. But in complex nervous systems, formed of inferior and superior centres connected by parts containing nerves that are centripetal, centrifugal, and commissural, there arise corresponding secondary functions which greatly obscure the primary functions. It remains true that all the afferent nerves are receivers of motions, and that all the efferent nerves are directors of motions; and it remains true that the vesicles and portions of grey substance throughout the centres are liberators of motions; but of the fibres largely composing these centres we must say that their functions are both receptive and directive. Nevertheless, we shall be considerably helped by thinking of the afferent nerves as *recipio-motor* and the efferent nerves as *dirigo-motor;* while we think of the nervous centres as composed of *libero-motor* elements along with elements that perform both the other functions.

This general conception has now to be made specific. In dealing with functions we will follow the same order as we did in dealing with structures—we will consider first the offices of the different kinds of nervous matter.

§ 19. The grey substance and the white substance—or, to speak more strictly, the nitrogenous matter in and around the vesicles and the nitrogenous matter occupying the centres of the nerve tubes—have not absolutely distinct duties. Certain simple animals yield evidence that in the rudimentary nervous system, there is no such structural differentiation and consequently no such functional differentiation; and there is proof that even in the highest animals the differentiation is incomplete.

On the one hand the vesicular substance, having for its chief office to give out molecular motion when disturbed, has also a considerable power of conveying or conducting molecular motion. When the fibrous parts of the spinal cord have been cut, it is found that if the central columns of grey matter remain uncut, or if there remains even a narrow link to maintain the continuity of the grey matter, disturbance is still communicated through it to the brain: not, indeed, disturbance of any special kind, but disturbance of the most general kind. True, it does not follow that such disturbance passes along the grey matter from end to end. Throughout the whole length of the spinal cord, nerve-fibres divested of their medullary sheaths enter into and afterwards issue from the grey matter; and, again protected by their sheaths, proceed upwards to the brain in the surrounding white matter. Very likely these take up and convey molecular disturbances set up in the grey matter imbedding them. But even this implies that disturbances are propagated to some extent through the grey matter; and the argument requires no more.

Conversely, it is found that the matter forming the "axis-cylinder," or essential nerve-thread, can do something more than transmit molecular motion. It has a certain power of simultaneously giving out molecular motion: so sharing the property of the vesicular matter. When a nerve is irritated not far above its termination in a muscle, the effect is but small. If the irritation is at a point further removed from the muscle, the effect is greater. And the effect increases as the length of nerve through which the disturbance is conveyed increases. From this we must infer that besides the molecular motion received and transferred, there is molecular motion liberated in the nerve-fibre itself. Not that this molecular motion, like that which the vesicular matter yields up, implies an equivalent decomposition. Probably it is a concomitant of the isomeric transformation propagated through a disturbed nerve, and serving to convey the disturbance. Some such accompanying result is to be inferred, *à priori*, if the conduction is effected by isomeric transformation, or by any kind of molecular re-arrangement. When the molecules of a mass change from one form of combination to another, either absorption or liberation of motion is sure to occur. That there cannot in this case be absorption of motion is manifest; since that would involve a proportionate resistance to the transfer—the amount of force or motion received by the extremity of the nerve, would quickly be used up in transforming the adjacent part of the nerve, and the change would travel but a little way. Being thus obliged to infer that motion is liberated, we at once see whence nerve-fibre derives the power to increase the disturbance it conveys; since each portion, while passing on the wave of molecular motion, adds the molecular motion given out during its own transformation. This action may be rudely symbolized by the transfer of sensible motion along a row of bricks on end, so placed that each in falling knocks over its neighbour. For if instead of bricks which stand on tolerably broad ends and require some force to overturn them, we suppose bricks that are delicately balanced on narrow ends; and if we further suppose them so constituted that they do not dissipate motion by percussion or friction; we shall see that the motion transmitted will accumulate. Each brick, besides the motion it receives, will pass on to the next the motion which it has itself gained in falling.

The general truths to be carried with us are, that in its primordial undifferentiated state, nerve-matter unites the properties of giving out molecular motion and conveying molecular motion; but that with the advance of evolution, it becomes specialized into two kinds, of which the one, collected together in masses, has mainly the function of giving out motion, though it can still to some extent conduct it, while the other, collected together in threads, has mainly the function of conducting motion, though it can still to some extent give it out.

§ 20. The co-operation of these differentiated kinds of nerve-substance, having differentiated functions, is seen in its simplest form where they are combined into what was before described as the unit of composition of the nervous system. An afferent nerve, changed by a touch at its outer end, and traversed by a wave of isomeric transformation that gathers strength as it goes, communicates this wave to the comparatively large mass of unstable matter connected with its inner end. The shock of molecular disturbance, immensely increased by the decomposition set up in this unstable matter constituting a ganglion-corpuscle or its matrix, diffuses itself around, but takes mainly the shape of a relatively-powerful wave of isomeric transformation along the efferent nerve. And the efferent nerve being distributed at its other end among the fibres of a muscle, this powerful wave sets up in them an isomeric transformation of another kind, resulting in contraction (*Principles of Biology*, § 303).

The belief that these are the offices of the respective parts, is borne out by those peculiarities of structure which were described as occurring in the afferent fibres of certain special sense-organs. We saw that the outer ends of the optic nerve, the auditory nerve, and the olfactory nerve, are alike characterized by the presence of vesicular matter; and that while in this they differ from the outer ends of the nerves of touch, they also differ in being excessively sensitive. If grey matter, or the matter of vesicles, has the function of immensely multiplying any molecular motion it receives, and passing on the augmented wave of change along connected fibres, we at once have a satisfactory explanation of these peculiar peripheral structures. Take as an example the retina. One of the minute cones in its sensitive layer, measuring not $\frac{1}{10000}$th of an inch in diameter, has its component matter changed by the etherial vibrations emanating from a candle in a cottage-window at a great distance. The infinitesimal impact received from so faint a ray, may well be supposed insufficient to send through a considerable length of afferent nerve, an adequately-rapid wave of molecular change; but this wave, after passing through an extremely delicate fibril less than $\frac{1}{100}$ of an inch in length, comes to a layer of ganglion-corpuscles, with one of which we may presume that it unites. In this the minute disturbance sets up destructive molecular change—unlocks a considerable amount of molecular motion; and thus greatly augmented, the wave of transformation traverses the remainder of the afferent nerve without that loss of time that would result had it to gain strength by a series of increments, starting from an infinitesimal first term.

How such appliances for multiplying action co-operate in these cases where the initial action is excessively minute, may be illustrated by certain artificial appliances that co-operate in an analogous manner. A man with a hair-trigger pistol in his hand, puts its muzzle to the end of a train that runs to a powder-magazine. The slightest pressure on the trigger liberates a spring, and this drives down the hammer. Here is something like the external multiplier which, as we have seen, habitually intensifies the action that falls on the end of an afferent nerve. The propelled hammer explodes the unstable detonating powder in the cap; thus playing a part comparable to that of the concentrated pencil of light, which causes decomposition in one of the minute sensitive rods or cones of the retina. The explosion of the cap explodes the powder in the pistol: a change that may symbolize the setting up of decomposition in an adjacent ganglion-cell by a disturbed retinal element. The flash from the mouth of the pistol fires the train, which, carrying the flame onwards, blows up the magazine; and this serves to illustrate the action of the partially-decomposed ganglion-cell which propagates a shock through the afferent nerve to a large deposit of unstable matter in the optic centre, where an immense amount of molecular motion is thereupon disengaged.

The joint action of an afferent fibre, its centrally-seated ganglion-corpuscle, and the connected efferent fibre, is commonly known as a reflex action. The name indicates the general truth that the disturbance in travelling from its place of origin to the place where its effect is seen, passes through a point at which its course is bent or reflected: and in so far as it describes this very general trait the term is a good one. But if the foregoing interpretation be correct, the term is in other respects objectionable. On the one hand, it implies as essential what is non-essential. That the wave of disturbance makes a sudden turn at one part of its course, is a fact of no intrinsic moment—is merely a concomitant of the fact that the nerves it traverses have to be put in communication with other nerves, and that points of junction imply angles. On the other hand, it leaves out of sight the fact that one of these points of junction from which the wave of disturbance is said to be reflected, is a place at which it is greatly augmented; and that this augmentation of the wave is the all-important office of the matter lying at the point of junction.

§ 21. Remembering that bundles of such afferent nerves are joined to bundles of such efferent nerves, by clusters of such corpuscles imbedded in the grey matter of a ganglion, and that bundles of centripetal nerves proceed thence to higher ganglia; we have next to consider the functions of these structures as wholes.

A nervous centre, even of an inferior order, is not simply a place where afferent nerves are severally linked with their corresponding efferent nerves, by corpuscles or portions of grey matter that multiply and pass on disturbances; nor is the only further office it serves that of sending to higher ganglia, portions of these disturbances; but it is also a place where more involved communications are effected. For in all ganglia save, perhaps, the very simplest, the corpuscles or vesicles give off processes more or less numerous, and usually more or less branched; and these branched processes, spreading through the matrix of grey matter, may be assumed to propagate in various directions, and various degrees, the disturbance set up in the corpuscle. This diffusion of liberated molecular motion has two implications. First, the number and complexity of the correlated changes produced by the original change, increase with the multiplication and variety of these processes and their connexions. And, second, along with increase in the number of correlated changes, there goes increase in the total quantity of molecular motion given out, directly or indirectly.

Fully to understand the importance of this last implication, it is needful to refer back to Fig. 4, and to the accompanying description of the way in which a nervous centre that serves to establish the various possible relations among different points in an organism, must contain a large accumulation of these connecting and multiplying links; and where it was shown how immense must become the accumulation of vesicular matter in a centre that has the office of establishing relations among these many parts in various orders. For it will be seen that as fast as the connexions become numerous and complex, so fast will enlarge the crowds of these connecting corpuscles and multipliers of disturbance which simultaneously come into action. And hence the quantity of molecular motion evolved in the nervous centres will become great in proportion as the nervous relations increase in integration and heterogeneity.

When we see how the arrangements for liberating and multiplying motion, described under their simple form in the last section, are thus compounded—when, recurring to our simile, we see how the first central magazine of force exploded, communicates with other larger magazines, and these again with still larger, which are subsequently exploded; we shall be at no loss to understand how the slightest impression on one of the *recipio-motor* nerves, may evoke from the *libero-motor* centres a relatively-incommensurable amount of force, which, discharged along the *dirigo-motor* nerves, may generate violent muscular contractions. So that, to take a case, a slight sound may produce a convulsive start of the whole body; or an unexpected motion of some adjacent object, infinitesimal as is the modification it produces in the retina, may nevertheless cause an involuntary jump and scream.

§ 22. In treating nervous functions in general, I have unawares ended with illustrations from the nervous functions of human beings: so coming to the division of the subject on which we have next to enter. For the brief account given in the last chapter of the special nervous structures with which we are most concerned, must here be supplemented by a brief account of their special functions.

If we leave out such afferent and efferent fibres as pass through the spinal cord to and from the encephalon, and also those centripetal and centrifugal fibres which connect its various parts with the encephalon, we may regard the partly dependent and partly independent centres composing the spinal cord, as being co-ordinators of the actions performed by the skin and muscles of the trunk and limbs. A large proportion of these actions, including many of considerable complexity, the spinal cord is able to co-ordinate without aid from the higher centres; and some of the partially-differentiated centres composing the spinal cord, are able to effect simple co-ordinations without aid from the rest. We will glance at these simple co-ordinations first. If a patient paralyzed by some injury of the spinal cord that has left the lumbar enlargement intact, has his foot touched, the leg is quickly withdrawn; not only without a cerebral act, but even without his brain being in any way affected, unless indirectly by the shaking of the bed. Thus the branched corpuscles and fibres contained at that point in the cord with which the afferent and efferent nerves of the leg are connected, have at once the function of giving out, when the disturbance is communicated to them, the requisite quantity of molecular motion, and of so directing this to the respective muscles of the leg, as to cause the appropriate movement. More involved co-ordinations are effected by the co-operation of several such centres, or portions of the grey substance, contained in adjacent parts of the spinal cord. In the human subject demonstration of this is not easy; but it is shown by experiments on inferior *Vertebrata*. A decapitated frog that has its side irritated, will bring the hind foot of that side to the spot, and move it so as to displace the irritating object. Even something further is done. If a scalpel be applied to the skin between the hind legs, these act jointly in such a manner as to push away the scalpel. The explanation is that by commissural fibres, transverse and longitudinal, the disturbances conveyed to particular centres, are communicated to sundry adjacent centres; and through their efferent nerves these direct and apportion the multiplied disturbances among a great variety of muscles. How such definite co-ordinations as these are effected by such an apparatus, we shall better understand on remembering that the relations between positions on the skin and the movements needed to bring the extremities to touch them, are tolerably constant. A frog's hind foot can reach a given point on the frog's side, only by one particular muscular adjustment; or, at any rate, by a muscular adjustment that varies within narrow limits. And since in all frogs, generation after generation, the proportions of parts, and therefore the relations of muscular adjustments to given positions, remain practically the same; it becomes comprehensible how, through the organized nervous connections that arise, a touch at any point may cause the combined contractions needful to bring the end of the limb to that point. It should be observed here, that the conception of these acts of the spinal cord as co-ordinations of motions, is incomplete so long as the only motions contemplated are those of the muscles. Under the head of motions must be included the disturbances conveyed along the afferent nerves; for the muscular motions are so adjusted that their joint results have special relations to these received disturbances. The co-ordination is between the *recipio-motor* acts and the *dirigo-motor* acts. We may, then, regard the spinal cord as a centre of co-ordinations which, though some of them have considerable complexity, are yet relatively simple—simple, inasmuch as the disturbances received from the skin are much alike from all parts; simple, inasmuch as each muscular adjustment is mainly of a fixed or invariable kind; and simple, inasmuch as the component acts of the co-ordinated group are practically simultaneous.

That enlarged and differentiated part of the spinal cord called the *medulla oblongata*, including the root-portion of the *pons Varolii*, adnate with it and structurally so entangled that the two cannot be demarcated, we may roughly distinguish as a centre of compound co-ordination. It receives directly the auditory impressions, the impressions of taste, and, indirectly through the *corpora quadrigemina*, is affected by visual impressions: meanwhile sending impulses to the various muscles of the eyes, the face, the jaws, and the mouth. By it the movements of all four limbs are combined in joint acts; and by simultaneously regulating them, it makes the head and jaws co-operate with the limbs. The various impressions and muscular motions implied by the act of swallowing, it brings into due relation. Receiving the respiratory stimulus, it emits the stimuli to those muscles which enlarge and diminish the thoracic cavity, so causing inspiration and expiration; and, as a consequence, it is the centre which, disturbed by the more violent irritations of the respiratory surface, sends out to the respiratory muscles those more violent impulses which cause coughing and sneezing: to which may be added, as actions belonging to the same class, crying and yawning. Lastly, through the pneumogastric nerve, it controls the action of the heart, and the actions of other viscera. Thus it is a centre to which come, in some cases directly but in most cases indirectly, impressions from all parts of the external surface, as well as from the mucous lining of the mouth, œsophagus, and lungs; and to which there also come, directly or indirectly, impressions received through the higher senses. At the same time the minor centres severally commanding groups of muscles, are by it put in relation with one another; and their respective simple actions so combined as to constitute compound actions. In short it has *recipio-motor* relations with all the parts that hold converse with the external world, while it has *dirigo-motor* relations with all the parts that react on the external world; and its function is that of adjusting the complex movements in obedience to the complex stimuli. This is not all. Being the centre which initiates and directs involved and extensive bodily actions, entailing rapid expenditure, it is the centre in which the demand for materials is indicated; and hence it becomes the regulator of the circulation, of the aeration of the blood, and of the visceral actions generally. Clearly, then, its co-ordinations are compound in comparison with those of the spinal cord—compound, because the impressions which afferent and centripetal nerves bring to it, are not only more numerous but also more heterogeneous; compound, because the impulses which it sends out are also more numerous and more heterogeneous; and compound, because it brings more involved acts into correspondence with more involved stimuli.

The functions of the two still higher centres, the *cerebellum* and the *cerebrum* have now to be defined in terms of the same nature. How shall we express them? Both of these great bi-lobed masses arise as buds out of the originally almost-uniform cranio-spinal axis; and as they enlarge, their distal portions grow more massive than their proximal portions, so that they end in being pedunculated. Each of them thus bears to the *medulla oblongata*, a relation like that which the superior ganglion H, in the diagrammatic Fig. 4, bears to the inferior ganglion F; and we may not unreasonably infer that their functions are analogous to those hypothetically assigned to the ganglion H. That is to say, we may regard them as organs of doubly-compound co-ordination—organs which have for their common function, the re-combining into larger groups, and into countless different orders, the already-complex impressions received by the *medulla oblongata;* and which have the further function of so arranging the already-complex motor impulses issuing from the *medulla oblongata*, as to form those far more involved aggregate actions, simultaneous and successive, which, being adjusted to these involved impressions, achieve remote ends. The general truth of this definition may, I think, be safely assumed; since it is simply a statement in other terms, of what, in ordinary language, is called intelligent action; which habitually characterizes vertebrate animals in proportion as these centres are largely developed. Thus much being granted, there arises the further question—what are the respective parts played by these two great organs in this doubly-compound co-ordination? Much difference of opinion has long existed, and still exists, respecting the particular offices of these supreme ganglia; and especially respecting the office of the *cerebellum*. Without committing myself to it as anything more than a hypothesis, I will here venture to suggest a not improbable interpretation. The common function of the two being that of co-ordinating in larger groups and in various orders, the impressions and acts co-ordinated in the lower centres, we may fitly ask—are there any fundamentally distinct kinds of order in which impressions and acts may be co-ordinated? The obvious answer is, that there are the two fundamentally distinct orders of Co-existence and Sequence. All phenomena are presented to us either as existing simultaneously or as existing successively. If, then, these two highest nervous centres, which together perform the general function of doubly-compound co-ordination, take separate parts of this function, as, from their separateness, we must conclude that they do; we can scarcely make a more reasonable assumption than that the respective orders in which they co-ordinate compound impressions and acts, answer to the respective orders in which phenomena are conditioned. In brief, the hypothesis thus reached *à priori*, is that the *cerebellum* is an organ of doubly-compound co-ordination in *space;* while the *cerebrum* is an organ of doubly-compound co-ordination in *time*. The *à posteriori* evidence, so far as I have examined it, appears congruous, both with this view of the general function of these centres, and with this view of their respective special functions. There is complete harmony between the hypothesis and the seemingly-strange facts that these centres may be partially destroyed without causing obvious incapacity, and that they may be wholly removed without destroying the ability to co-ordinate the less complex impressions and acts. Assuming, as we may fairly do, that the cells and fibres which subserve the more involved co-ordinations, are successively added at the surfaces of these centres as they develop, it is inferable that the superficial parts may be sliced off with the least-appreciable effects on the actions; and that the effects on the actions will become conspicuous in proportion as the slices destroy the parts nearer to the lower centres: and these are the results established by experiment. Besides finding, as the hypothesis leads us to expect, that these nervous masses are relatively large in all creatures capable of adjusting their involved and continuous actions to complex and distant environing agencies; we also trace some relation between the development of each and the peculiar capacities of the species. There is, for instance, the fact that the *cerebellum* is unusually developed in birds of prey, which have to co-ordinate with great accuracy the relations of distance, direction, and complex form, as well as very precisely to co-ordinate the involved movements appropriate to these involved impressions. And there is, on the other hand, the fact that the *cerebrum* predominates in creatures showing, like ourselves, the power of adapting, throughout long periods, concatenated compound actions to concatenated compound impressions.*

Of course this classification of the functions of the nervous centres, as co-ordinations that are simple, compound, and doubly compound, must be taken as merely approximate. No definite divisions can be made. The functions arise through increasing complications; and these general contrasts become conspicuous only when we look at the facts in their main outlines. Here, however, where the

* Let me here draw attention to papers in the *Medical Times and Gazette*, for December 14 and December 21, 1867, in which Dr. Hughlings Jackson has published some facts and inferences that quite harmonize with these interpretations, in so far as the common function of the great nervous centres is concerned.

It should be remarked that the above-proposed definitions, are, to a considerable extent, coincident with current conceptions. The *cerebrum* is generally recognized as the chief organ of mind; and mind, in its ordinary acceptation, means more especially a comparatively intricate co-ordination in *time*—the consciousness of a creature "looking before and after," and using past experiences to regulate future conduct. In like manner the function ascribed to the *cerebellum* in the foregoing paragraph, partially agrees with that which M. Flourens inferred from his experiments. It differs, however, in two respects. It implies that the *cerebellum* is not an organ for the co-ordination of motions only, or of synchronous motions only; but that it is also an organ for the co-ordination of simultaneous impressions, and for the co-ordination of the synchronous motions in adaptation to the simultaneous impressions. And it further implies that not all simultaneous impressions and adapted synchronous motions are co-ordinated by the *cerebellum*; but only the doubly-compound ones, which have for their external correlatives the intricate combinations of attributes that distinguish objects from one another, and the more multiplied and varied localizations of objects in the space that extends beyond the immediate limits and reach of the organism.

object is to give an idea of the principles of nervous function in its successive stages of evolution, detailed qualifications do not concern us.

§ 23. A few words are due to the functions of that subordinate nervous apparatus, the structure of which we glanced at in the last chapter—the nervous apparatus presiding over the vital processes. It will suffice if we take the functions of the vaso-motor division of it as exemplifying the whole.

Each vaso-motor nerve, having roots in both the cerebrospinal system and the sympathetic system, conveys to all branches of the artery it accompanies, the impulses arising from the activities of the great nervous centres and muscles, as well as from the activities of the viscera. Probably the ordinary amount of disturbance propagated along each vasomotor nerve, simply excites the muscular coats of the adjacent artery sufficiently to maintain its due elasticity. But stronger disturbances produce marked alterations of its calibre: those brought by the sympathetic fibres being said to cause contraction; and those brought by fibres from the cerebro-spinal system being said to cause dilatation. Some of these changes have relation to actions going on in the part itself; and others to actions going on in the chief vital organs, or in the body as a whole. But all of them show us that by means of the vaso-motor nervous system, the blood-vessels are so regulated as to subserve general and local needs. One further fact belonging to this class may be added; partly because of its intrinsic interest, and partly because it illustrates certain supplementary nervous functions not hitherto named. We have already seen that, among its many duties, the *medulla oblongata* controls, through the medium of the pneumogastric nerve, the action of the heart. So long as the disturbance conveyed to the *medulla oblongata*, either from the periphery of the nervous system or from its great centres, does not exceed a moderate amount, the resulting waves of molecular change sent by it through the pneumogastric, do not interfere with the heart's action—perhaps enforce it. But when the *medulla* is excessively disturbed, the increased quantity of stimulus it sends, either diminishes the action of the heart, or stops it altogether: so causing arrest of the circulation and consequent insensibility. Noting, as we pass, that this is one of the most remarkable forms of that co-ordination which the nervous system everywhere effects, since the arrangement is such that when the nervous system becomes abnormally active, and its chief centres surcharged with blood, they themselves arrest the organ which propels blood to them; we have to ask how it happens that in this case the propagation of disturbance through a nerve checks action instead of causing it. The reply is that in addition to the systems of nerves which excite action, there is found to exist a system of nerves which diminish action—*inhibitory* nerves as they are called. Through these it is alleged that the brain controls the spinal cord—restraining those reflex movements which, when connection with the brain is cut off, become so much more marked. And through one of these it is concluded that the *medulla oblongata* reins in the heart, when the cerebral irritation is excessive.

Be this as it may, the facts named illustrate the way in which the nervous system, while it co-ordinates the external actions, also co-ordinates those internal actions which make them possible. The reader has but to conceive that through other systems of nerves, other organs which absorb, secrete, excrete, &c., are similarly controlled, and he will understand sufficiently for present purposes, how demand for materials and supply of materials are harmonized.

§ 24. In summing up the functions of the nervous system as thus formulated in terms of motion, it will be useful to observe the greater comprehensiveness of view we obtain by excluding the ordinary implications.

When one part of a Zoophyte is touched, the contraction set up in that part slowly diffuses itself through the whole body. Two things are here to be noted. There is a propagation of disturbance through the nerveless sarcode of which the creature is composed; for distant parts are eventually affected. There is also an increase of disturbance; for in successive moments the mass of tissue undergoing change is greater. Thus the relatively-homogeneous substance of these simple animals, exhibits the two essential phenomena exhibited by the nervous system in all phases of its development: there is propagation of molecular motion, and there is a simultaneous augmentation of this molecular motion. Such essential phenomena grow more conspicuous as the nervous system develops, partly because the changes set up become limited to narrow lines and small masses, and partly because the matter of which these are formed becomes distinguished by an increased degree of the general instability. Since, then, the functions of the nervous system as expressed in terms of molecular motion, are functions exhibited in a vague way by the undifferentiated tissue from which the nervous system insensibly arises; it is clear that by so expressing them we include alike their lowest and their highest forms, which we cannot otherwise do.

Moreover, only in these terms can there be given an adequate definition of fully-developed nervous functions. If we admit any subjective element, our definition becomes inapplicable to all those nervous actions which have no subjective accompaniments—which go on without feelings; and a conception of nervous functions which excludes those of organic life, cannot be a complete conception. On the other hand, the definition of nervous functions as consisting in the conveyance and multiplication of molecular motions, holds in all cases. It includes equally the conduction of an impression made on a nerve of sense, and the excitement of chemical metamorphoses in a gland.

The subdivision of this general function under the above-proposed heads of *recipio-motor*, *libero-motor*, and *dirigo-motor*, has also the advantage of greater comprehensiveness. No word at present in use expresses the office which afferent nerves have in common, more specifically than the word afferent itself expresses it. Whether disturbance of its outer end produces in an afferent nerve a change causing a reflex contraction, or whether it produces a change causing what we call a sensation, is a circumstance of secondary import; as is proved by the fact that by use the last may become the first. The essential thing common to the two, is that molecular motion is propagated from periphery to centre. So, too, is it with the *libero-motor* functions. Whether, as in the ganglia of the sympathetic, the multiplication of communicated disturbance has no subjective concomitant, or whether, as in the *cerebrum*, it has a subjective concomitant, there is in both cases a liberation of molecular motion; and this, being the common character of the changes in nerve-centres, must determine the definition of their common function. In like manner, all efferent nerves, whether conveying disturbances that set up contractions in muscles, or cause constrictions of arteries, or excite chemical transformations in glands, serve to direct the waves of molecular motion—waves that are intrinsically alike in nature, though the results produced by them in the organs to which they are carried differ so widely, and though they are now associated with consciousness and now are not.

A more special view of the functions thus classed, discloses two essential facts. Considered as an agent for generating movements, we see that the nervous system acts by liberation of successively-larger amounts of molecular motion in the centres successively disturbed. A very small change at the outer end of an afferent nerve, sets up a relatively-large quantity of change in some adjacent unstable nerve-matter; whence the change, thus increased, is propagated to some internal ganglion; to be passed on by it immensely multiplied as before; until there is unlocked an amount of disturbance capable of causing muscular contractions throughout the whole body.

Meanwhile these centres in which molecular motion is liberated, are also the centres in which it is co-ordinated; and the successively higher and larger centres which evolve successively larger quantities of molecular motion, are also centres in which successively more complex co-ordinations are effected. Whence follows the general result that along with each further development of the nervous system, enabling it to make all parts of the body work together more efficiently in simultaneous and successive actions, there goes an increased power of evolving the energy required for such larger aggregates of actions.

These principles we found to be well exemplified in the case which most nearly concerns us. It is needless to re-state the results so recently arrived at. One remark, however, may be added. In the functions of the successively-higher vertebrate centres, reaching their climax in the human being, we see well exemplified the law of development of functions in general (*First Principles*, Part II. § 142). This progress from co-ordinations that are small and simple to those that are larger and compound, and to those that are still larger and doubly compound, is one of the best instances of that progressive integration of motions, simultaneously becoming more heterogeneous and more definite, which characterizes Evolution under all its forms.

CHAPTER IV.

THE CONDITIONS ESSENTIAL TO NERVOUS ACTION.

§ 25. Of these, the first in order is continuity of nerve-substance. Disturbance is not conveyed from end to end of a nerve that has been cut in two; and section of a nerve-centre similarly prevents the transfer of an impulse from one of the dissevered parts to the other.

The requisite continuity is not simply the continuity of unbroken contact: there must be continuity of molecular cohesion. Placing in apposition the two ends of a divided nerve, does not re-establish nervous communication. Even when, after a cut, the surrounding flesh has been healed, it is long before the sundered nerve-threads re-unite so completely that they transmit stimuli as well as before.

Further, there must be no destruction of continuity by molecular disorganization. Without division of a nerve, and without injury of its sheath, there may result from disease a change which incapacitates the nerve-fibres—an atrophy, or a breaking-up by decomposition: the result being a derangement of those lines of peculiar nitrogenous molecules which receive and pass on the waves of disturbance.

§ 26. Nerve-structures, whether peripheral or central, permanently disabled as they are by actual discontinuity, either molar or molecular, are temporarily disabled by discontinuity of molecular equilibrium. Pressure is capable of producing re-arrangement of particles, even in substances that are simple and comparatively hard; as is shown by its power of altering the direction of diamagnetic polarity in metals. We may therefore expect that in substances of complex composition and little cohesion, pressure will readily cause the particles to change their relative positions. Hence there is no difficulty in understanding why nerve-substance, having a balanced molecular structure such that it is ever ready to pass when disturbed from one of its isomeric states to the other, may be so modified by pressure, even when small, as to be incapacitated for undergoing these alternate molecular re-arrangements. Be this as it may, however, the fact is that one of the conditions to nervous action is absence of much pressure.

In the case of nerve-trunks, demonstration of this general truth is easy. A ligature round a nerve prevents a disturbance set up at one end of it from producing any effect at the other end. Partial results of this nature are familiar. By external pressure on a limb, the conducting power of the nerves affected is much diminished.

That pressure on the centrally-seated tracts of fibres, hinders or arrests their actions, is shown in every case of paralysis. By a clot of blood that has escaped from a ruptured vessel, or by a quantity of lymph that has oozed through the walls of capillaries over-distended, bundles of fibres at the base of the brain, or in the spinal cord, are unduly squeezed; and if afferent or centripetal fibres they cease to bring disturbances from the periphery, while if efferent or centrifugal fibres they cease to convey impulses to the muscles.

The like is true of nerve-centres as wholes. Indeed pressure appears to be a greater hindrance to their actions than to the actions of nerve-trunks. That certain forms of the abnormal arrest of nervous action called coma, are due to excessive congestion of the blood-vessels of the encephalon, seems possible; but as some question this interpretation we cannot safely base an inference on it. There is, however, one conclusive piece of evidence. A fracture of the skull that causes indentation over a considerable area, and leaves the bone intruding on the space previously filled by the brain, stops the functions of the brain—disturbances sent to it call forth no appropriate co-ordinated motions, and, indeed, no motions at all. But when, by means of a trephine, the depressed portion of bone is cut out, the brain, relieved from pressure, at once resumes its duties.

Further support is yielded by what may be regarded as converse evidence. If excess of pressure arrests nerve-action, and if the normal amount of pressure allows the normal amount of nerve-action; then it is inferable that nerve-disturbances will pass with undue facility if the pressure is deficient. Now as the brain is contained in an almost-closed chamber which cannot collapse, it follows that if the cerebral blood-vessels are rapidly drained, the masses of nerve-fibres amid which they ramify, being subject to less pressure than usual, will allow waves of molecular change to pass with unusual facility; and ordinary impressions propagated to the centres, will produce extraordinary motor impulses. Hence the seemingly-anomalous fact that great loss of blood, or great local anæmia caused by stoppage of a cerebral artery, causes convulsions. Such a result may be anticipated as the first result, before innutrition begins to tell; though innutrition will afterwards cause prostration or paralysis. And this is the order in which the phenomena actually occur. The like appears true of the peripheral nervous system. The afferent nerves of individuals who, though otherwise healthy, have lax tissues, are often unduly impressible. And there are instances of undue local impressibility which, I think, admit of this interpretation. It has been found that an arm rendered anæmic by unnatural constriction of its arteries, thereby reduced in temperature and beginning to atrophy, may nevertheless have its afferent nerves affected by electric discharges in an unusual degree.* Deficient pressure on the nerve-trunks appears a possible cause of this otherwise strange result.

§ 27. Proof that heat kept above a certain level is a condition to the maintenance of nervous action, is difficult to disentangle from proof that the maintenance of nervous action depends on a due circulation of blood; for the one condition is usually but a concomitant of the other. Nevertheless, there is reason to infer that a supply of free molecular motion is requisite, apart from a supply of nutritive materials.

The general fact that cold-blooded animals are comparatively inactive, admits of the interpretation that their low temperature is due to their inactivity, as well as of the interpretation that their inactivity is a consequence of their low temperature; for the two act and react in such a way that neither can properly be called the cause of the other. But reptiles which remain quiescent in cold weather, and become active when they are warmed by the summer's sun, yield us good evidence. Though it may be alleged that their greater activity arises from accelerated circulation and aeration of the blood, yet as the heart and lungs are set going by their respective nervous centres, we must infer that the warming of these nervous centres by external heat, is the initial change in these animals that have but little power of producing heat by their own actions. In support of this interpretation may be cited the converse fact. When active creatures, capable under ordinary conditions of generating enough heat within themselves, are exposed to conditions under which they lose heat faster than they make it, their nervous actions decrease, and they eventually cease to move. In hybernating mammals we see

* I am indebted for this fact to Dr. Bastian, who observed it in one of his own patients.

an annual recurrence of this relation of cause and effect; and in mammals that do not hybernate, as in ourselves, it equally holds that prolonged exposure to extreme cold depresses nervous action, causing strong tendency to sleep, and that death results if the bodily temperature is allowed to fall still lower.

That local loss of heat when carried far, is followed by local inaction of the nerves, is shown by the fact that parts of the body that have been greatly cooled down, naturally or artificially, may be pricked or cut or pinched without any of the usual disturbances being conveyed to the nerve-centres. It is true that where the refrigeration is extreme, there is usually a partial deprivation of blood; but there is evidence that when this is not the case—when, indeed, the blood-vessels are congested, as in red hands on a winter's day, loss of heat entails decrease of nerve-function. That the like holds of the respective centres, is shown by the use of cold as a therapeutic agent: ice to the head being prescribed when there is excessive cerebral action, and ice to the spine being a means of diminishing reflex excitability.

It is worth remarking that this dependence of nervous action on supply of heat, yields indirect support to the views set forth in foregoing chapters. If, as was inferred, the disturbance conveyed along a nerve-thread is an isomeric change, during which some molecular motion is yielded up by each molecule as it passes on the accumulated wave to its neighbour—if resumption of the previous isomeric state implies an equivalent absorption of molecular motion from surrounding matter; then, in proportion to the heat of surrounding matter, will be the rapidity with which the nerve-fibre, resuming this previous isomeric state, becomes fit to transmit another wave of molecular change.

§ 28. That nerves and nerve-centres act only so long as they are furnished with those materials which the blood-vessels bring them, is a familiar truth. The quantity of blood present in any part, and the rapidity with which fresh blood is propelled to the part, both affect the degree of nervous activity in the part.

General depletion is a cause of nervous inaction: if the total quantity of blood in the body is much diminished, the great nervous centres are the first organs to feel the change. Temporary loss of blood produces fainting, or sudden arrest of cerebral action; and permanent deficiency of blood is accompanied by debility, which implies a decreased nervous discharge. Supposing that no blood has been lost, insensibility nevertheless instantly results if the heart ceases to supply the brain with fresh blood in place of the blood it contains. Or if there is chronic feebleness of the heart's action, there is proportionate diminution of nervous power. Where the total quantity of blood is adequate and the heart is not in fault, local nervous function may still be hindered by local anæmia, resulting from aneurism in an artery, or from what is called an embolism—a plugging up of an artery with coagulated blood. Thus paralysis is caused by embolism of the cerebral blood-vessel which supplies the highest part of the motor tract. The converse facts similarly imply this same general relation. When, other conditions being normal, a nerve-centre is highly charged with arterial blood, it responds with unusual rapidity to the disturbances it receives; and evolves more than ordinary amounts of force, shown in secondary nervous changes, or in muscular motions, or both. Supposing, again, that there is no hyperæmia of a nervous centre, it will still happen that if the heart propels blood to it with unusual rapidity, its libero-motor function will be exalted.

At the periphery of the nervous system, like variations of efficiency follow like variations of circulation. A reduction in the quantity of blood present, caused by constriction of the vessels, is probably one cause of the decreased nervous impressibility in a part that is exposed to cold; and to the same cause is perhaps to be ascribed some of the comparative sluggishness with which the muscles of the part respond to motor impulses. If instead of local lack of blood there is retardation or stoppage of the local current of blood, the nerves of the part similarly become incapacitated in a proportionate degree: instance the blindness that results from blocking up the central retinal artery; or instance the gradual disappearance of impressibility in a region of the skin that has had its supplying blood-vessel tied. Conversely, excess of blood around the peripheral nerve-fibres, causes unusual excitability of them. A gentle touch on the skin in its normal state, sends through the afferent nerves a disturbance so small as to call forth from the central organs scarcely any response; but where the skin is highly inflamed, a like touch affects them so much that the disturbance, when reflected from the central organs, produces a start of the whole body. If in addition to local excess in the quantity of blood there is an accelerated flow of blood, a still greater exaltation of local nervous action follows. It is a familiar truth that, other things remaining the same, an inflamed part is made more irritable by anything which increases the action of the heart.

§ 29. Nervous action depends not alone on the quantity of blood supplied but also on its quality—on the proportion of the needful elements contained by it.

General rather than special warrant must suffice for this proposition. Little is known about variations in the constitution of the blood; and still less about the relations between these and variations of nervous activity. That a blood greatly impoverished, as in dropsical persons (whose tissues become infiltrated because the thin serum passes too easily through the walls of the capillaries), is accompanied by enervation, is pretty clear; and we can scarcely be wrong in concluding that a blood rich in the constituents of nerve-substance, renders possible a great evolution of nerve-force.

But there is indirect evidence serving to enforce the scanty direct evidence. For we have abundant proof that by adding certain matters to the blood, unusual amounts of nervous action may be evoked. Alcohol, nitrous oxide, the vegeto-alkalies, and other stimulants, are not, indeed, components of nerve-substance; nor is there any reason to suppose that they can serve in place of components. Probably their immediate influence is that of setting up or facilitating the change of nerve-substance, and so causing unusual disengagement of molecular motion. But by showing that the supply of particular substances to the nervous system exalts nervous activity, they make it more manifest that nervous activity must partly depend on the supply of substances which re-build nerve-tissue as fast as action disintegrates it.

We must not omit a further qualitative character of a positive kind. The blood must contain oxygen. What is the special action of oxygen—whether it is a direct disintegrant of the tissues, including nerve-tissue; or whether it simply facilitates by its presence molecular disintegrations otherwise caused; or whether it serves merely to combine with, and carry away, the products of such disintegrations otherwise caused; are questions about which there are differences of opinion. But there can be no difference of opinion as to the necessity for an oxygenated blood. And opinions can scarcely differ respecting the general relation that exists between the degree of oxygenation and the degree of nervous activity.

§ 30. While, for the maintenance of nervous action, it is requisite that certain matters shall be present in the blood, it is also requisite that certain other matters shall be absent; or, to speak strictly, that they shall be present in but small proportions. These are the compounds resulting from decomposition of the tissues—the nervous tissue included. The two most important are carbonic acid and urea.

If the exhalation of carbonic acid by the lungs is greatly retarded, lethargy ensues: disturbances at the periphery of the nervous system fail to call forth the usual responses. If the exhalation is completely arrested, complete insensibility is soon produced; followed quickly by arrest of the inferior nervous functions, and consequently of all other functions. And these effects arise still more rapidly if there is an absorption of carbonic acid through the lungs, instead of an arrested excretion of the carbonic acid internally generated.

In an analogous but less rapid manner, a decrease and final stoppage of nervous action is caused by an accumulation in the blood of urea, or of those nitrogenous products represented by it. If the kidneys fail to perform their function, or if the waste nitrogenous products which they have separated from the blood are prevented from escaping out of the body, and are re-absorbed; there results a nervous inaction, ending presently in coma and finally in death.

§ 31. Such, stated as fully as is needful here, are the conditions essential to nervous action. Qualifications have been passed over; and much evidence has been omitted. In summing up these leading facts which alone concern the psychologist, we may with advantage observe how they harmonize with the general views of nerve-structure and nerve-function set forth in foregoing chapters. All these pre-requisites to nervous action obviously admit of being grouped as pre-requisites to the genesis of molecular motion, and pre-requisites to the conveyance of molecular motion.

That molecular motion may be disengaged there must be decomposition; and, therefore, for the discharge of molecular motion to be maintained, decomposition must be facilitated. The quantity of waste being a measure of the quantity of force evolved, it follows that the nervous system requires a good supply, and quick exchange, of blood; since in the blood are brought the matters that favour disintegration. Similarly with respiration, considered as a process of absorbing that oxygen which directly or indirectly aids the metamorphosis. And so likewise with the excretion of those waste products which hinder the metamorphosis. But perpetual waste must be met by perpetual repair. If its action is to continue, nervous tissue must be re-composed as fast as it is decomposed. Hence the reason why there is needed a blood that is rich in nerve-constituents. Hence the fact that abundant blood must be present wherever there is much nervous action. And hence, also, the necessity for an efficient circulation to replace by fresh blood, the blood that has been used.

Equally well do the several conditions essential to the transmission of nervous disturbance, conform to the hypothesis that the disturbance transmitted is a wave of isomeric change. For if it is, we at once see why there must be not merely contact-continuity of nerve-fibre, but molecular continuity. We are helped to understand how pressure, by deranging that delicate molecular balance which makes possible the alternation of isomeric states, may prevent the passage of nervous discharges. And we are supplied with an explanation of the fact that the presence of free molecular motion or heat, is needful to enable a nerve continually to resume its fitness for conveying a wave of change.

Before closing the chapter it should be pointed out that these many conditions essential to nervous action, are never all fulfilled at one time in the same degree, but are usually fulfilled in various degrees and combinations; and that by now conspiring and now conflicting, they produce results that are complicated and often perplexing. Thus, for instance, substances which directly stimulate the nervous system, are usually substances which retard the exchange of gases in the lungs, and by so doing depress the state of the nervous system; and these conflicting actions, different in their proportions in different individuals, and in the same individual at different times, often work opposite effects, or work first one effect and then the other. Again, richness of blood, by facilitating high nutrition of nerve-centres, conduces to nervous activity. Yet there is a plethoric state which is not nervously active; and starvation, with its greatly impoverished blood, has a phase at which delirium sets in, in consequence of the unduly rapid disintegration of the nerve-centres. Analogous incongruities, too numerous to specify here, continually occur. This entanglement of the conditions must be borne in mind and allowed for in each case.

CHAPTER V.

NERVOUS STIMULATION AND NERVOUS DISCHARGE.

§ 32. Every agent capable of altering the molecular state of a nerve, causes the nerve to produce the particular change which it habitually produces. Experiments prove that each nerve is made to work the same kind of effect by stimuli of all orders; or, to speak strictly, it is found that the effect is of the same kind wherever its kind renders it accessible to observation.

Thus, if an exposed end of a nerve which goes to a muscle is roughly touched, the muscle contracts. If it is eroded by an alkali or an acid, the muscle contracts. If it is galvanized, the muscle contracts. If it is suddenly heated, still the muscle contracts. Similarly with a vaso-motor nerve. No matter whether the disturbing agent be mechanical, chemical, thermal, or electric, there results at the peripheral extremity a like change in the state of the adjacent arteries.

An allied truth is that whether a nerve be irritated at the end which normally receives the disturbance, or whether it be irritated at some place between this and the organ acted upon by it, the effects wrought are alike—in nature, at least, if not in degree. As already said, the *quantity* of change set up increases with the length of the nerve through which the impulse is transmitted. But the *quality* of this change remains identical be the stimulus applied at a near point or a remote point.

This last truth, equally with the first, harmonizes with the supposition on which we have thus far proceeded. If the disturbance that travels along a nerve is a wave of isomeric transformation, the kind of effect produced by the wave at the place it eventually reaches, will be the same whatever stimulus set it up, or wherever it commenced.

§ 33. Nerve is not capable of continuous stimulation or continuous discharge. Persistent action of whatever kind on a nerve-termination or the cut end of a nerve, does not produce a persistent effect on the connected nerve-centre, or on the connected peripheral organ.

Supposing the nerve supplying some muscle has been dissected out and cut in two; then, if the exposed part be suddenly pressed the muscle will suddenly contract; but maintenance of the pressure will not cause maintenance of the contraction. Or if this nerve is made part of an electric circuit, then, at the moment of completing the circuit, the muscle will contract; but its contraction is only momentary, and the subsequent continuance of the current works no visible effect. To keep up muscular contraction, it is requisite to send through the nerve a quick succession of separate disturbances. If the nerve forms part of an electric circuit in which there is an apparatus for breaking and completing the circuit; then, at each completion of the circuit, the muscle contracts; and when the alternate breaks and completions follow one another very rapidly, the contraction of the muscle becomes practically persistent. This truth is demonstrable by experiment on a dead frog, and also by experiment on the living human subject. A man who grasps the two metallic cylinders forming the poles of a magneto-electric machine, cannot leave hold of the cylinders when the intermittent current is passed through his arms. The like result occurs when the disturbances are mechanical instead of electric. If the cut end of a motor nerve is subject to a rapid series of taps, the muscle it supplies is thrown into a state of tetanus.

The fact that the so-called nerve-current consists of successive pulses, is one of great significance. We shall find hereafter that it has many important corollaries. For the present it will suffice to observe how entirely congruous it is with the hypothesis on which we have thus far proceeded. If a nervous disturbance travels as a wave of molecular change—if this wave is such that the molecules of nerve-substance fall from one of their isomeric states to the other; then, having fallen in passing on and increasing the pulse or shock, they remain incapable if doing anything more until they have resumed their previous isomeric state. Hence the very nature of the process necessitates the intermittent character of nerve-action.

§ 34. The transmission of a disturbance through a nerve takes an appreciable time. The rate of transmission, as measured by Professor Helmholtz, has been found to vary from about 28 yards per second to 32 yards per second. Difference of constitution is doubtless the cause of this variation—a variation to which is due that individual peculiarity recognized by astronomers in what they call "the personal equation."

This peculiarity affords yet another confirmation of the belief that a nervous discharge is a wave of isomeric transformation. If the disturbance propagated through any series of molecules is one that does not permanently change their relative positions; then the transfer of the disturbance may be excessively rapid, because the amount of molecular momentum to be generated is excessively minute. But if the molecules have to be transposed—if, as in isomeric transformation, the components of each compound molecule have their relative positions altered; then the quantity of molecular momentum generated must be comparatively very large;

and as the genesis of this momentum takes place in each molecule before the next is affected, the transfer of the disturbance must be greatly retarded.*

* Perhaps too much has already been said respecting the nature of nerve-action. But before finally leaving the subject, I must add some important illustrative facts that have come to my knowledge while writing this chapter. They are contained in a paper by Mr. Gore, published in the *Transactions of the Royal Society* for 1858, describing the allotropic changes undergone by electro-deposited antimony. Antimony so deposited assumes, according to the conditions, two forms—a dark, amorphous, or unstable form; and a grey, crystalline, or stable form. When a mass of the amorphous antimony is disturbed at one end, there begins a change into the crystalline antimony, which spreads almost instantly throughout the whole mass, with great evolution of heat. A slight tap with a hard substance suffices to initiate this transformation. Touching one of the angles with a hot body equally produces the effect. And it is also produced by an electric spark. A temperature below that of boiling water sufficed to cause the change; and Mr. Gore found that in proportion as the whole mass was raised towards this temperature, the metamorphosis, more easily set up, travelled with greater rapidity. When a copper wire was coated with a film of this amorphous antimony, the allotropic change progressed along it at a rate varying from 12 to 30 feet in a minute. Absorption of the evolved heat by the copper wire, was found to be the cause of retardation when the change advanced slowly; whence it follows that were none of the disengaged heat allowed to escape, the wave of change would travel much faster. A further significant fact is that when this transformation was propagated through some amorphous antimony that had been previously reduced to powder, part of it was oxidized—the disturbance caused by the allotropic change initiated chemical change, in parts of the substance that were favourably circumstanced for chemical change. See then the parallelism. We have the transformation set up indifferently, as in nerve, by mechanical force, heat, electricity. We have it facilitated, as in nerve, by raised temperature. We have it travelling from end to end of a mass with a velocity which, though far less than that of the nerve-wave, is still considerable. And we have allotropic change initiating chemical change, just as we concluded that isomeric change in a nerve-fibre sets up chemical change in a nerve-vesicle. Let me not omit an interpretation of nerve-structure, which is suggested by Mr. Gore's experience that the transmission of the allotropic change is rapid in proportion as the evolved heat is retained. In developed animals, nerve-fibres are surrounded by sheaths of medullary matter; and we saw reasons for concluding that this medullary matter is an insulator. Now it has recently been discovered that white or fibrous nerve-tissue, is chemically distinguished from grey or vesicular nerve-tissue, by the

§ 35. Allied with the fact that a nerve-disturbance takes an appreciable time to travel from periphery to centre or from centre to periphery, is the fact that the effect produced

presence in large quantity of a substance called *protagon;* and this substance proves to be of excessively complex composition—has a molecule more highly compounded than any other known molecule. But in proportion as molecules become complex and large, the masses formed of them become bad conductors of molecular motion. It is inferable, then, that the essential nerve-fibre is imbedded in a substance especially distinguished by inability to absorb the molecular motion disengaged during the isomeric change of the nerve-fibre.

I have hitherto passed over without remark, the hypothesis at one time current, and still surviving in some minds, that the nervous force is either electricity or some form of force allied to it. In addition to the many foregoing reasons for adopting another hypothesis, it may be well to set down here the reasons for rejecting this. The highest rate of the nervous discharge is some 32 yards per second. The electric discharge travels at the rate of 280,000 miles per second. The one velocity is thus nearly 16,000,000 times the other. That a force allied to the electric should have a velocity so enormously different, seems very unlikely. Again, an electric current, so long as its source is unexhausted and the circuit unbroken, is a continuous current; but the nerve-current is not continuous. Hence if the nerve-force is of a kind allied to the electric, its mode of alliance is quite exceptional; for the other allied forces, heat, light, and magnetism, are not intermittent. Once more, nervous transmission is facilitated by heat; whereas heat is an obstacle to electric transmission, and diminishes or destroys magnetic action. The fact is that but for the accidental observation of Galvani, the suspicion that the nerve-force is electric or quasi-electric, would probably never have been entertained; and it should have been abandoned as soon as it was found that other disturbing agents, physical and chemical, work just the same effects. The conception has, indeed, been kept alive by the discovery that electricity is generated by certain fishes. But the supposed support is wholly imaginary. If because the Torpedo evolves electricity by the help of nerves ramifying through its electric organ, it is inferred that the nerve-force is electricity; it may in like manner be inferred that the nerve-force is sensible motion, because it generates sensible motion in muscles. But, it may be asked, do not the experiments of Du Bois-Reymond yield support to the hypothesis? A very doubtful support I think. The phenomena he describes may well be merely incidental accompaniments of actions that are in themselves neither electric nor quasi-electric. The truth that both molar and molecular changes in the distribution of matter habitually destroy the electric equilibrium, would be a sufficient general justification for this belief. But there is a special justifiat the centre or at the periphery lasts an appreciable time. That muscular contraction is continuous though the stimulus is intermittent, goes to show this. The genesis of molecular modification in muscle by the molecular modification in the nerve-fibres permeating it, has a duration that bridges the interval between each pulse of stimulus and the next. We have no direct proof that a like continuity of state results from the successive waves propagated to a nerve-centre; for the actions of which nerve-centres are the seats are not objectively perceptible. But we shall presently find abundant indirect proof that these changes also last for measurable periods.

This general truth, like its predecessor, may be regarded as a corollary from what has gone before. The transformations classed as chemical take time, equally with those classed as isomeric. It is true that explosions due to chemical action are what we call instantaneous (a description of them which is not, however, scientifically accurate; as may be perceived when the matter exploded is of con-

cation. Direct proof exists that the particular kind of molecular change we have supposed to take place in nerve, and in muscle, is adequate to produce the phenomena observed by Du Bois-Reymond. Mr. Gore found that if a copper-wire, coated with amorphous antimony, formed part of an electric circuit, it happened that whenever the allotropic change propagated along the antimony stopped, the galvanometer-needle was deflected. Now, since during the maintenance of a muscular contraction, nerve-pulses are continually arriving and ceasing, and the muscular fibres (never all in action together) are at every instant some of them contracting and some relaxing, it follows that there will be a succession of stoppages of isomeric changes. Consequently there will be a maintenance of deflection in the galvanometer if a contracted muscle forms part of the electric circuit.

[Since this note has been in type, I have referred to the lecture delivered by M. Du Bois-Reymond at the Royal Institution on April 13, 1866, "*On the Time required for the Transmission of Volition and Sensation through the Nerves*," for the purpose of verifying one of the statements above made; and I find that at the close of this lecture he goes a long way towards abandoning his hypothesis. Though he says, "it would be rash, as the matter stands, entirely to dismiss the notion of electricity being concerned;" and though he sketches out a theory of nerve-composition such as makes it conceivable that an electric disturbsiderable bulk). But explosions occur only in those exceptional cases where the elements concerned are either, as in detonating compounds, distributed among one another molecularly, or, as in gunpowder, with minute intimacy. In ordinary cases, where sensible masses of the elements concerned are external to one another, the chemical actions, limited to the surfaces of contact, proceed with comparative slowness. Now the granular protoplasm contained in and around nerve-vesicles, forms, with its permeating liquids and the blood in adjacent capillaries, a mass of which the components are but imperfectly interfused; and therefore a chemical change cannot pass through it instantly. Hence between the reception of a pulse of molecular motion by a nerve-centre, and the emission of a gush of molecular motion, or discharge, some little time must elapse.

§ 36. If a nerve-centre that receives a stimulus through an incoming nerve, undergoes a chemical change and sends

ance might travel along a nerve at the observed rate (basing this, however, on the gratuitous assumption that the molecules of nerve-matter have north and south poles); yet he admits that much evidence points another way. He says that "to identify it (the nervous agent) with the electric current as it circulates in a telegraph-wire must appear hopeless, even if a circuit, such as would be necessary for the supposed nerve current to circulate in, were anatomically demonstrated. Thus to the other arguments against this view of the nervous agent—that the resistance of the nerve-tubes would be far too great for any battery to send an available current through them—that the physiological insulation of the nerve-tubes from each other would be impossible to explain—that the effect of ligature or of cutting the nerve and causing its ends to meet again, would be equally obscure—to these arguments, unanswerable as they are in themselves, the researches sketched in this lecture have added corroborative evidence of the highest order. What we have termed the nervous agent, if we look upon its very small velocity, in all probability is some internal motion, perhaps even some chemical change, of the substance itself contained in the nerve-tubes, spreading along the tubes, according to the speaker's experiments, both ways from any point where the equilibrium has been disturbed; being capable of an almost infinite number of variations or gradations, and of so peculiar a character as to require the unimpaired condition of the nervous structure."]

a discharge along out-going nerves, it thereupon becomes less capable of emitting such discharges in response to such stimuli. The quantity of molecular motion locked up in a nerve-centre, is measured by the contained quantity of unstable nerve-matter; and decomposition of that part of the unstable nerve-matter which was most favourably placed for being acted on, leaves not only a diminished quantity but a quantity that is less favourably placed for being acted on—leaves, therefore, a decreased readiness to undergo change when disturbed, as well as a decreased stock of molecular motion to be liberated. Consequently, other things remaining the same, every excitation of a nerve-centre reduces, for a time, its impressibility and its energy.

This temporary enfeeblement of a nerve-centre, when caused by moderate action, is inconspicuous. The disintegrated mass quickly re-integrates itself from the materials brought by the blood. But if the stimulation and consequent discharge are violent, or if stimulations and discharges are repeated very rapidly, then repair falls so far in arrear of waste that partial or entire incapacity of the nerve-centre results. All its unstable substance within easy reach of in-coming disturbances has been decomposed; leaving such part only of its unstable substance as is most removed from disturbances, and can be affected only by excessive ones. A well-known experiment on the vaso-motor system of a frog, may be cited in illustration. If a frog's foot be placed under a microscope, and so adjusted that the arteries ramifying through the transparent membrane between the toes are brought into view, then, if a powerful irritant be applied to this membrane, the first result observed is that these arteries are violently constricted —the strong impression conveyed to the vaso-motor centres there liberates an excessive discharge along the fibres supplying these arteries, causing spasmodic contractions of their muscular coats. The second result is that these arteries dilate: losing their normal contractility they become distended with blood, and the part is, as we say, congested. That this is due to extreme prostration or temporary paralysis of the vaso-motor centre, has been clearly proved; for if the nerve-trunk containing the vaso-motor fibres be dissected out and artificially irritated, the dilated arteries instantly contract. How a nerve-centre may be prostrated by a rapid succession of moderate stimuli and discharges, instead of by one violent stimulus and discharge, is shown by the familiar effect of friction on the human skin. A single moderate rub causes only a slight reflex action on its vessels, and leaves the vaso-motor apparatus ready to act afresh with no apparent diminution of power. But a series of rubs is followed by temporary congestion of the vessels: it is some little time before the vaso-motor centre regains its full control over them. And if the skin be continuously chafed, the excessive waste and debility of the vaso-motor centre entail that enduring redness called congestion. Those parts of the nervous system concerned in muscular action, daily illustrate the same general relation. Fatigue is a state in which the ability to generate motion has been greatly diminished by long-continued genesis of motion; and every tired horse shows, by the small response he makes to a cut of the whip, that a more violent impulse must be propagated to the nerve-centres to cause the ordinary evolution of nervous energy.

Irregularities in the manifestation of this truth, are due to that entanglement of the conditions which was indicated at the close of the last chapter. It frequently happens, for instance, that after performing its function for some time, a nerve-centre responds to the demands on it better than at first—a fact apparently at variance with the foregoing conclusion. But this conclusion supposes all the circumstances to have remained the same; and in such cases they have not remained the same. There has been an exaltation of the heart's action, or a local increase in the quantity of blood, or a more rapid aëration of blood, or all of these. When every appliance which furthers the disintegration and re-integration of a nerve-centre, has been brought into full play, both waste and repair go on faster; and there result greater impressibility and energy than when the previously-unused centre contained but little blood languidly circulating.

§ 37. Were Life uniform in its rate—were terrestrial conditions such that actions of all kinds could be performed as readily at one time as at another, repair and waste of all organs, including nervous organs, would have to keep an approximately-even pace, one with the other. But the alternation of day and night entails an alternation of greater and less facility for actions; and there has resulted in organisms an adapted alternation in the relative rates of waste and repair. The adaptation is manifestly due to survival of the fittest. An animal so constituted that waste and repair were balanced from moment to moment throughout the twenty-four hours, would, other things equal, be overcome by an enemy or competitor that could evolve greater energy during the hours when light facilitates action, at the expense of being less energetic during the hours of darkness and concealment. Hence there has necessarily established itself that rhythmical variation in nervous activity, which we see in sleep and waking. Let us observe how these are interpretable, the one as a state of the nervous centres in which waste has got considerably in excess of repair, and the other as a state in which repair has made up for previous excess of waste.

Confining ourselves to persons whose functional rhythms have not been deranged by undue excitements, we see that after some sixteen or eighteen hours of sustained impressibility and energy, there is a diminished readiness to respond to stimuli that fall on the eyes, ears, and surface of the body at large; and presently this becomes so pronounced that loud sounds and the irritations produced by strained attitudes, fail to evoke movements. When great exertion has been gone through, or when previous intervals of sleep have been omitted, the decrease of impressibility is such that tickling the nostrils or pinching the skin does nothing more than cause, perhaps, a reflex start. This change, so marked and often so rapidly established, seems greater than the alleged cause can produce; but it is fully accounted for when we include an indirect effect of this cause. The waste of the nerve-centres having become such that the stimuli received from the external world no longer suffice to call forth from them adequate discharges, there results a diminished impulse to those internal organs which subserve nervous activity, including, more especially, the heart. Consequently the nerve-centres, already working feebly, are supplied with less blood and begin to work more feebly—respond still less to impressions, and discharge still less to the heart. And so the two act and re-act until there is reached this state of profound unimpressibility and inactivity.

Between this state and the waking state, the essential distinction is a great reduction of waste. Certainly in some nervous centres and probably in all, waste does not absolutely cease: there continue those emissions of force which keep up the vital processes; and it is, I think, unlikely that there is ever an entire stoppage of those changes which take place in the highest centres. But the rate of waste falls so low that the rate of repair exceeds it. It is not that during the period of activity waste goes on without repair, while during the period of inactivity repair goes on without waste; for the two always go on together. Very possibly—probably even—repair is as rapid during the day as during the night: perhaps even more rapid: for the blood is on the average richer and circulates faster. But during the day the loss is greater than the gain, whereas during the night the gain is diminished by scarcely any loss. Hence results accumulation: there is a restoration of the nerve-tissue to its state of integrity.

In the course of some hours this restoration begins to show its effects in returning impressibility. While in sleepiness we see a decreasing readiness to respond to external stimuli, the approach to a waking state is characterized by an increasing readiness to respond to external stimuli. Throughout the period of quiescence the afferent nerves remain subject to incident forces. The pressure of the body on the bed affects some of them, and others are affected by the touch of the bed-clothes; degrees of heat a little above or below the average, act on others; and yet others receive sonorous vibrations constantly occurring. But whereas sleep results because the centres worn by action become less and less sensitive to these stimuli, waking results because the centres repaired during rest become more and more sensitive to them. The strains of muscles and ligaments which during the first part of the night fail to cause changes of attitude, cause such changes towards morning. The amount of light that traverses the eye-lids presently suffices to call forth movements. Some slight noise which, hours before, would have had no effect, now produces a start. Even in the absence of external stimuli (which, however, can never be absent) there are the stimuli from the viscera, and especially from the alimentary canal: an empty stomach eventually sends to the cerebro-spinal system enough disturbance to end the quiescent state. The longer repair goes on unopposed by appreciable waste, the greater must become the instability of the nerve-centres, and the greater their readiness to act; so that there must at length come a time when the slightest impressions will produce motions. Such impressions, however slight, are necessary antecedents. The re-integrated nerve-centres do not resume their activity until an impulse arriving from the periphery overthrows some of their molecules. Evidence of this is furnished to most every morning. On awakening from refreshing sleep, there commonly occurs an involuntary stretching of the muscles of the whole body; showing an immense undirected motor discharge. But this is not the initial fact. No one awakes to find himself then and there stretching; which might happen were the discharge spontaneous. It comes after those stronger disturbances that are propagated to the centres, as soon as some slight disturbance has led to the slight movements that accompany waking. A trifling sound causes opening of the eyes and a turn of the head. Thereupon follow vivid impressions through the eyes, through the skin that rubs against the bed-clothes, and through the muscles that set up the movements. And a relatively-large aggregate of stimuli being sent from the periphery, there results this relatively-large gush of motor excitement.

On pursuing the argument we may understand why the energies continue to rise for some time after waking. We saw that when once sleepiness has commenced, it increases because in proportion as the nervous centres fail in their discharges, the heart, losing part of its stimulus, begins to flag, and that the flagging of the heart leads to a greater inertness of the nerve-centres, which re-acts as before. Conversely, it will here be manifest that when the nerve-centres, repaired by sleep, become again ready for discharging with vigour, there take place an action and re-action which have the opposite effect. The pulsations on awaking are comparatively feeble. As soon as stimuli begin to be received through the sensory organs, and the discharges of the nerve-centres are renewed, the heart comes in for its share of these and acts more vigorously. By so doing it supplies the nerve-centres with more blood in quicker gushes. A greater nervous discharge is thereby made possible, which again, among other results, exalts the heart's action. And so the mutual aid goes on: the greatest nervous vigour being reached when the vascular activity has been still further raised by a meal, and the blood has been enriched by the absorbed materials.

§ 38. As implied by much that has gone before, and as especially implied by the last section, nervous stimulation and nervous discharge have always both special and general results. Beyond the primary and definite effect wrought on a particular part by a particular impression, there are in every case secondary and indefinite effects diffused through the whole nervous system, and by it through the body at large.

It was pointed out (§§ 10, 11) that the simplest nerve-centre puts in relation not afferent and efferent fibres alone; but that through other fibres, commissural and centripetal, connections are made between it and other nerve-centres of the same grade and of a higher grade. Further, we saw that when such a nerve-centre is excited through an afferent nerve, the disengaged molecular motion does not escape wholly along one or more efferent nerves; but that part of it, propagated to higher centres, there sets up supplementary changes. The diffusion does not stop here—remoter parts are reached; and thus the disturbance of a single nerve-fibre, if at all considerable, reverberates throughout the entire nervous system, and affects all the functions controlled by it. Digging a pin into the foot may cause a convulsive contraction not of the leg-muscles only, but of many other muscles throughout the body. At the same time it may alter the rate of pulsation, and send waves of constriction along the arteries. The excreting structures of the skin may be so affected that a burst of perspiration results; and the actions going on throughout the alimentary canal may be deranged. Such reverberations, which become conspicuous when the disturbances are decided, take place also when they are slight. A more vivid light, causing as it does stronger pulses of change through the optic nerve, increases the rate of respiration; and doubtless the other vital functions are simultaneously exalted. So that each nervous impression, beyond a direct response in the shape of increased action from one or more organs, calls forth an indirect response in the shape of increased action of the organism as a whole.

Remembering that every instant the disturbance thus echoing throughout all passages of the nervous system is not solitary, but that there are many such disturbances, here arising from pressure there from touch, in this place produced by sound and in that by light, at one part by muscular strain and at another by heat or cold; it will be manifest that, besides the few distinct waves of nervous change working their distinct effects, there are multitudinous indistinct waves, secondary and tertiary, travelling in all directions working their indistinct effects.

§ 39. Since such reflected and re-reflected disturbances everywhere act as stimuli, we must regard the entire nervous system as at all times discharging itself. The unstable molecules of its centres, exposed to this confused reverberation, are liable to be decomposed wherever a concurrence of small waves makes the local agitation considerable; and the molecular motion thereupon disengaged, adds to the centrifugal gush perpetually going on. Rightly to conceive nervous action then, we must think of the conspicuous emissions of force from parts of the nervous system that are strongly disturbed, as standing out from a vague back-ground of inconspicuous emissions from the whole nervous system, which is slightly disturbed.

To this general nervous disturbance with its consequent general discharge, is probably due a certain general action of the motor organs. No muscles are ever in a state of absolute rest. What we distinguish as muscular motion is produced by the greater contraction of some muscles than of others. The others, however, are all slightly contracted; and would severally produce motion were they not balanced or out-balanced by their antagonist muscles. This pervading activity of the muscles is called their tonic state. And while we regard particular contractions as the results of particular nervous discharges, we have good reasons for concluding that this universal contraction is the result of the universal nervous discharge. Here are a few of them. Sleep, as above explained, implies diminished nervous discharge, special and general. A diminution of the general discharge ought, then, to be shown in a decrease of the tonic contraction. It is so shown. Falling asleep is accompanied by muscular relaxation: though previously the attitude was such that no effort seemed requisite to maintain it; yet that there was some muscular strain, and that it has suddenly become less, is proved by the sliding down of a limb, or of the head, to a more stable position. Certain disorders, as palsy, yield further proof. The flexors and extensors which, when duly contracted, serve by their balanced antagonism to hold a limb steady, cease to do this when the general nervous discharge is not great enough to keep them and all other muscles braced up: in default of sufficient stimulus for both, now one set and now the other fails to put the due check on its opponent. That such shakings are so caused, we see clearly in persons debilitated by over-stimulation; for in them this symptom may be temporarily mitigated, or almost cured, by temporarily increasing the general nervous discharge. The drunkard who early in the day cannot lift his glass without spilling the contents, is able to do this after his brain has been excited by the usual doses of alcohol.

Of course it is not the muscles alone on which this continuous centrifugal gush is expended. Through the intermediation of nerves connecting the cerebro-spinal system with the sympathetic system, the viscera receive their share of it. Hence the overflow of nervous energy which, without special solicitations, diffuses itself throughout the motor structures, giving elasticity to the step, and producing the concave bend of the back, the opened-out shoulders, the raised head, &c., has, for its simultaneous results, an accelerated circulation, an invigorated digestion, and an exaltation of the vital processes at large.

§ 40. Briefly reviewed from a somewhat different standpoint, the following are the leading facts which it concerns us to remember.

Nervous stimulations and discharges consist of waves of molecular change, that chase one another rapidly through nerve-fibres. The stimulus or discharge formed of such waves, arises at some place where unstable nerve-substance has been disturbed; and is the same no matter what agent caused the disturbance. The successive waves severally travel with a velocity which, though considerable compared with ordinary sensible motions, is extremely slow compared with other kinds of transmitted molecular motions. And each set of waves, while itself caused by the decomposition of unstable nerve-matter, is a means of decomposing other unstable nerve-matter: so generating further and often stronger sets of waves, which similarly chase one another into many and distant parts of the nervous system.

There is a triple rhythm in these nervous stimulations and discharges—each form of rhythm being due to the greater or less incapacity for action which an action produces. We have seen that every wave of isomeric transformation passing along a nerve-fibre, entails on it a momentary unfitness to convey another wave; and that it recovers its fitness only when its lost molecular motion has been replaced and its unstable state thus restored. We have also seen that any portion of grey matter in a nerve-centre, which having been disturbed and partially decomposed has emitted a shock of molecular change, is proportionately incapacitated; and that it recovers its original ability only as fast as it re-integrates itself from the materials brought by the blood. And then there comes the further rhythm constituted by the alternations of sleep and waking—a rhythm having the same origin as the last, and being supplementary to it.

The remaining truth which we have contemplated is that each special stimulation and the special discharge produced by it, do not together form the whole of every nervous act;

but that there is always an accompanying general stimulation and general discharge. Every part of the nervous system is every instant traversed by waves of molecular change—here strong and here feeble. There is a universal reverberation of secondary waves induced by the stronger primary waves, now arising in this place and now in that; and each nervous act thus helps to excite the general vital processes while it achieves some particular vital process. The recognition of this fact discloses a much closer kinship between the functions of the nervous system and the organic functions at large, than appears on the surface. Though unlike the pulses of the blood in many respects, these pulses of molecular motion are like them in being perpetually generated and diffused throughout the body; and they are also like them in this, that the centripetal waves are comparatively feeble while the centrifugal waves are comparatively strong. To which analogies must be added the no less striking one, that the performance of its office by every part of the body, down even to the smallest, just as much depends on the local gushes of nervous energy as it depends on the local gushes of blood.

CHAPTER VI.

ÆSTHO-PHYSIOLOGY.*

§ 41. Throughout the foregoing chapters nervous phenomena have been formulated in terms of Matter and Motion. If from time to time the phrases used have tacitly referred to another aspect of nervous phenomena, the tacit references have formed no parts of the propositions set down; but have

* This new word will possibly be condemned as not legitimately compounded. The objection that the root from which its prefix is derived, is shorn of its fair proportions, admits, I am told, of a satisfactory answer: from the proximate root, appeal may be made to the original root, which, following the Greek method of forming derivatives, would admit of the required modification. But to the criticism that the word involves the logical inconsistency of uniting a verb with a noun, there is no such sufficient answer. Nevertheless, I deliberately adopt *Æstho-physiology* in preference to the more cumbrous and cacophonous *Æsthesi-physiology*. A progressive integration by which the originally-distinct and numerous parts of compound words become fused together, blurred, and some of them lost, is one of the essential processes in the development of language. If mankind had refrained from the obliteration and disfigurement of roots, and parts of roots, language would have continued wholly inadequate for all but its simplest functions. Omitting those formed by onomatopœia, the best words are those from which long use has worn away all, or nearly all, traces of their origin. We may as well, therefore, begin with abbreviated and modified words when we have to coin them; instead of leaving time to bring about the needful shortening and shaping. Those who, dealing with words as counters, see that their convenience as counters is the chief consideration, will probably coincide in this view; though I suppose it will be wholly disapproved by those who regard words not as counters but as money.

been due to lack of fit words—words free from unfit associations. As already said, the nervous system can be known only as a structure that undergoes and initiates either visible changes, or changes that are representable in terms furnished by the visible world. And thus far we have limited ourselves to generalizing the phenomena which it thus presents to us objectively.

Now, however, we turn to a totally-distinct aspect of our subject. There lies before us a class of facts absolutely without any perceptible or conceivable community of nature with the facts that have occupied us. The truths here to be set down are truths of which the very elements are unknown to physical science. Objective observation and analysis fail us; and subjective observation and analysis must supplement them.

In other words, we have to treat of nervous phenomena as phenomena of consciousness. The changes which, regarded as modes of the *Non-Ego*, have been expressed in terms of motion, have now, regarded as modes of the *Ego*, to be expressed in terms of feeling. Having contemplated these changes on their outsides, we have to contemplate them from their insides. To speak with exactness, indeed, it cannot be said that *we* have so to contemplate these changes; for this expression implies that these changes can be simultaneously seen by more than one, which is not true. Rigorously limiting the proposition to that which is alone possible, it amounts to this:—I have to describe the laws of relation between the states of feeling occurring in my own consciousness, and the physical affections of that nervous system which I conclude I possess; and the reader has to observe whether in himself there exist parallel relations between such known states of consciousness and such supposed nervous affections.

This will perhaps be thought a needlessly roundabout, if not a sceptical, statement; but it is in fact not roundabout enough. It does not bring sufficiently into view the remotely-inferential character of the belief that feeling and nervous action are correlated. Before proceeding on this belief, let us observe how indirect is the path which leads to it.—1. Each individual is absolutely incapable of knowing any feelings but his own. That there exist other sensations and emotions, is a conclusion implying, in the first place, the reasonings through which he identifies certain objects as bodies of like nature with his own body; and implying, in the second place, the further reasonings which convince him that along with the external actions of these bodies, there go internal states of consciousness like those accompanying such external actions of his own body. 2. This conclusion that there exist beings like himself, and that under like conditions they experience like feelings, even supposing it entirely true (and it is not entirely true, for many facts unite to prove that under like conditions both the quantities and the qualities of sensations and emotions in different individuals differ considerably), by no means implies that what he knows under its subjective aspect as feeling, is, under its objective aspect, nervous action. The average observer has no direct evidence that these other like beings have nervous systems, any more than that he has himself a nervous system; and he has no direct evidence in the one case any more than in the other, that nervous excitations are the causes of feelings. Experimental physiologists and pathologists only have proofs; and even their proofs are mostly indirect. The experiments which yield them are usually made on beings of another and much inferior order. The contractions of muscles and arteries, caused by irritating nerve-trunks in frogs, the convulsive movements, and sometimes the sounds, made by birds and mammals whose nerve-centres are variously injured—these are the phenomena from which it is inferred that the human nervous system is the seat of the human feelings, and that these feelings are the correlatives of its excitations: the only important verifications of the inference being those obtained during surgical operations where nerve-trunks are cut through, and those furnished by *post mortem* examinations of morbid nervous structures in the bodies of those who when alive displayed abnormal excesses or defects of feeling. 3. And then, having learnt at second hand, through the remotely-inferential interpretation of verbal signs, that in now one and now another of the bodies he recognizes as like his own there has been found a nervous system, and that the stimulations of this produce those manifestations which in himself accompany feelings, the reader imagines a nervous system contained in his own body, and concludes that his sensations and emotions are due to the disturbances which the outer world sets up at its periphery, and arouses by indirect processes in its centres. Such, stated as briefly as possible, is the long and involved series of steps by which alone the connection between nervous action and feeling can be established.

Nevertheless, the evidence of this connection is so large in amount, presents such a congruity under so great a variety of circumstances, and is so continually confirmed by the correct anticipations to which it leads, that we can entertain nothing more than a theoretical doubt of its truth. Here accepting the belief, alike popular and scientific, that all the human beings known objectively have feelings like those which each knows subjectively; and accepting also the belief, originating with science but now diffused through the general mind, that feelings are the concomitants of nervous changes; we will proceed to consider the relation between feelings and nervous changes under its leading aspects.

§ 42. And first let us observe that the circumstances conducive to the one are identical with the circumstances conducive to the other. The conditions which we before found essential to the production of nervous action, we shall now find essential to the production of feeling. We may pass over the evidences briefly, as being many of them the inner aspects of phenomena already observed under their outer aspects.

That without continuity of nerve-fibre between periphery and centre, a disturbance at the one causes no feeling at the other, is proved to every one who has cut himself deeply: for a long time the part that has had its nervous communication destroyed, remains numb. This experience, usually very limited in each person, is borne out by the testimony of those seriously injured; and especially by the testimony of those whose sensations over large parts of their bodies have ceased, and who, after death, are found to have lesions in the conducting structures of the nervous centres.

The hindrance or prevention of feeling by pressure, is illustrated by the numbness of a limb so placed that its whole weight, and perhaps the weight of another limb lying over it, comes on the edge say of a table; so that great stress is borne by some portion of the chief nerve-trunk. Local anæsthesia thus caused in strong persons, is caused still more readily in feeble persons; who, on awaking, not unfrequently find complete insensibility of the parts that have been pressed against the bed during sleep.

Ability to feel depends on the maintenance of a certain temperature. This also is a general truth of which some proof is furnished to every individual by his own experience—or, at any rate, to every individual inhabiting a climate where the winter's frost suffices greatly to chill the extremities. Evidence much stronger but indirect, is given him by those who have undergone surgical operations in parts deprived of feeling by freezing mixtures or by ether-spray. Loss of local sensibility from local cold, ordinarily not very manifest unless the cold is great, becomes manifest when the cold is slight if the circumstances supply a delicate test. This is interestingly shown among compositors. The air of a printing-office has to be kept very warm, even at the expense of unhealthy closeness; otherwise the fingers of the compositors cease to lay hold of, and manipulate, the types with the requisite nicety and speed.

Few persons have immediate experience of the fact that defect of blood in a part causes defective sensibility of that part; but all persons have immediate experience of the local exaltation of sensibility that accompanies local excess of blood. The inflamed neighbourhood of a wound, or even the surface of a pimple, yields to consciousness when touched, an amount of feeling far greater than is yielded by a part of the skin supplied with the ordinary amount of blood. Special organs of touch show us well the increased sensitiveness thus caused. When one of those sacs containing the bulbs of the small hairs scattered over the skin, is congested, the rubbing of the clothes against the hair growing from it, especially if it has been broken short, produces an unbearable smart. Among evidences yielded by the other senses, a familiar one is the intolerance of light that goes along with inflammation of the eyes. And there is an unfamiliar one particularly worth noting, because it exhibits the effect due to increased quantity of blood apart from increased temperature. The observation may be made when taking a hot bath. Let the water be above blood-heat—say 100° Fh. After remaining quiet for a time until equally heated all over, stand up and rub one portion of the body with a flesh-brush until it is red. Pause a few moments, and lie down again in the water. It will then be perceived that to the reddened part the water seems much hotter than it does to any other part.*

That degree of feeling is affected by quality of blood as well as by quantity, is a truth not easily discerned within the

* This fact yields proof, if there needs any, that the nerves which appreciate temperature are not the nerves of touch. Violent friction must produce a momentary incapacity of the nerves of touch; and this incapacity would be shown in a decreased, instead of an increased, appreciation of temperatnre, were they the agents concerned.

experiences of each individual, if attention is limited to those variations of feeling that accompany naturally-produced variations in quality of blood. For such variations cannot be identified with precision; and they arise so slowly that the concomitant mental states cannot be brought into close contiguity, so as to bring out their contrasts clearly. But by making certain artificial additions to the blood, every one gets proof of the connection between its quality and the genesis of feeling. The effects of stimulants on consciousness are mostly traced in the intensification of those internally-initiated feelings with which we shall deal presently; but they may also sometimes be traced in the intensification of the externally-initiated feelings. In nervous subjects, ordinary impressions on the senses are often rendered abnormally acute by tonics. When under the influence of opium, music that was previously unenjoyed may be greatly enjoyed; and it is a well-known result of hashish to give an excessive vividness to the sensations.

How, contrariwise, there are substances which, when added to the blood, render sentiency less vivid, is shown by other facts similarly reached. We have sedative medicines—medicines that diminish the amounts of painful consciousness caused by irritations at the periphery of the nervous system. And we have agents of the same class called anæsthetics, which, in a still greater degree, hinder the genesis of feelings by the actions that usually generate them. These effects so caused, help us to understand the stupor produced by the natural anæsthetics, carbonic acid and urea; and prove that some variations in degree of feeling are determined by variations in the activities of excreting organs.

§ 43. Now that we have noted how feelings and nervous changes are facilitated or hindered by the same conditions, we may go on to collate them in detail. Let us begin by distinguishing those nervous changes which are accompanied by feelings from those which are not. For, as we noted in passing, several classes of them have objective aspects only —do not present inner faces to consciousness; and others have subjective aspects in early life but cease to have them in adult life.

Chief among the nervous changes that have no identifiable subjective aspects, are those occurring in the visceral nervous system. So long as they are normal in their amounts, the stimulations and discharges of which the sympathetic is the seat, go on without sensations; and even when abnormal, the resulting discomfort or pain is probably not due to them but to disturbance of those cerebro-spinal fibres which accompany the sympathetic through all its branchings. Similarly with the local ganglia and fibres of the heart. Ordinarily there is no consciousness of the heart's action; and even when the pulsations are violent, the modifications of consciousness do not arise from the state of the heart's nervous system, but from disturbance of cerebro-spinal nerves caused by the bounds of the heart against adjacent structures. The like holds with the vaso-motor nerves. Under ordinary conditions these regulate the diameters of the arteries without our knowing anything about it; and though where, as in a blush, great dilatation of the vessels has been produced, we are made aware of their action, yet we are made aware of it indirectly, through the local change in the quantity of blood and the consequent effect on the nerves that appreciate temperature.

The majority of stimulations and discharges occurring in the spinal cord, have subjective accompaniments. These, however, are not localized at those points in the spinal cord where the essential nervous changes take place; as is proved by the fact that when some lesion of the spinal cord which has not injured its lower part, has cut off communication with the brain, the reflex acts performed by this lower part are unconscious. Proceeding upon the inference before drawn (§ 21) that when a wave of disturbance brought by an afferent nerve to a spinal centre, liberates a quantity of molecular motion, a portion of it, not discharged along the efferent nerves, is propagated through a centripetal nerve to a higher centre, we may conclude that it is this portion which comes, in the higher centre, to have a subjective aspect as a sensation: being there joined with other sensations and feelings of other orders into a chain of states of consciousness, out of which no sensation is ever known to exist. For recognition of a sensation as such or such, necessitates the bringing of it into relation with the continuous series of sentient states, from some of which, simultaneously experienced, it is dissociated by perceived unlikeness, and with others of which, previously experienced, it is associated by perceived likeness; and the implied comparisons of sentient states are impossible unless the correlative nervous changes are put in connexion at one place. It does not follow, as it at first seems to do, that feelings are never located in the inferior nervous centres. On the contrary, it may well be that in lower types the homologues of these inferior centres are the seats of consciousness. The true implication is that in any case the seat of consciousness is that nervous centre to which, mediately or immediately, the most heterogeneous impressions are brought; and it is not improbable that in the course of nervous evolution, centres that were once the highest are supplanted by others in which co-ordination is carried a stage further, and which thereupon become the places of feeling, while the centres before predominant become automatic.

Quite congruous with this conception is the above-named fact, that certain nervous changes which have subjective sides early in life cease to have them later in life. Many acts performed by the child slowly and consciously, the adult performs rapidly and unconsciously. Every step taken during the first efforts to walk has its accompanying distinct feelings; but eventually, the successive steps are made while consciousness is wholly or almost wholly occupied with other feelings. Still better is the illustration furnished by speech. Each muscular adjustment of the vocal organs and each articulate sound made, have, in childhood, concomitant sentient states that are vivid, and, for the moment, all-absorbing. Gradually, however, these become less dominant in consciousness; until at maturity there is entire oblivion of the one, and sometimes partial oblivion of the other: witness the not unfrequent verbal mistakes unconsciously made in the heat of discussion. Now facts of this kind, countless in number and of many varieties, are explicable if we regard feelings as the subjective sides of such nervous changes only, as are brought to the general centre of nervous connections. When we remember that early in life each inferior ganglion, or cluster of co-operating inferior ganglia, is imperfectly organized, and the connections among its fibres incomplete; we shall see that if there comes to it a disturbance, the gush of molecular motion liberated, not having in the incompletely-connected commissural and efferent fibres, adequate channels of escape, will part of it escape along a centripetal fibre to a higher centre, so awakening a feeling. And it will manifestly happen that the approach to automatic action of the lower centre, will be an approach to a state in which the liberated molecular motion, having in the efferent fibres fully-opened channels of emission, will little or none of it be forced into centripetal fibres, and will so awaken little or no feeling. It is a corollary from this interpretation, that all gradations will exist between wholly unconscious nervous actions and wholly conscious ones; since there will be all gradations in the relative amounts of the disturbances which take their courses along centripetal fibres. It obviously follows, too, that in adult life a nervous action may or may not have an identifiable subjective aspect, according as it is strong or weak; since, if there comes to a finished ganglion constructed as described, a feeble disturbance, the whole of the small quantity of molecular motion liberated may be drafted off by the efferent fibres; whereas, if the disturbance is great, the disengaged molecular motion, being more than can find its way along the efferent fibres, will some of it take a centripetal course and cause a subjective change.

§ 44. A kindred aspect of this correlation presents itself when we contemplate feeling as occupying time. A subjective state becomes recognizable as such, only when it has an appreciable duration: it must fill some space in the series of states, otherwise it is not known as present. This general truth harmonizes with a general truth before pointed out respecting nervous action, as well as with the above interpretation.

The observed fact that time is taken in the transit of a nerve-wave, is not to the point; for this transit has no concomitant subjective state. But the inferred fact that the change set up in a nerve-centre must take time, and a more considerable time (§ 35), is relevant; for what is objectively a change in a superior nerve-centre is subjectively a feeling, and the duration of it under the one aspect measures the duration of it under the other.

That feeling persists after the force arousing it ceases, is not proved by the lengthened sensation produced by a moderate blow on the skin, or by that which follows dipping the hand into hot-water, or by those which the palate and the nostrils experience from pungent substances momentarily applied; for though in such cases the external action of the exciting agency is brief, the local changes it sets up, lasting some time, continue for some time to disturb the local nerve-fibres. But good evidence is supplied by impressions on the retina. To quote the words of Professor Huxley:—" A flash of lightning is, practically, instantaneous, but the sensation of light produced by that flash endures for an appreciable period. It is found, in fact, that a luminous impression lasts for about one-eighth of a second; whence it follows, that if any two luminous impressions are separated by a less interval, they are not distinguished from one another. For this reason a 'Catherine-wheel,' or a lighted stick turned round very rapidly by the hand, appears as a circle of fire; and the spokes of a coach-wheel at speed are not separately visible, but only appear as a sort of opacity, or film, within the tire of the wheel."

As above said, this general truth that feeling implies time, harmonizes with the interpretation given in the preceding section; and supplies a further elucidation of the relation between conscious and unconscious nervous action. For manifestly, in proportion as nervous co-ordinations become more automatic they become more rapid; and for this reason also, cease to present such conspicuous subjective aspects. Returning to the inferior ganglion, or cluster of co-operating ganglia, above described, it will be obvious that a state in which the local organization is incomplete, and the various afferent and commissural fibres not brought into definite relations with vesicles, and through them with efferent fibres, must be a state in which the molecular motion liberated by an incoming shock of change, will pass through the imperfectly differentiated structure with comparative slowness; and there will therefore be an appreciable time during which centripetal fibres may receive disturbance. But as fast as the local connections of fibres and cells become complete, the gush of molecular motion, following the completely-formed channels, will escape rapidly; and the period during which excitement of the centripetal fibres may take place will be abridged. The concomitant subjective state will therefore be rendered shorter by the same change that renders it feebler.

§ 45. The fact that each feeling lasts an appreciable time, introduces us to the allied fact that each feeling produces a greater or less incapacity for a similar feeling, which also lasts an appreciable time. This, too, is the subjective side of a phenomenon before noticed under its objective side (§ 36). For as the duration of a feeling answers to the duration of the molecular disintegration in a disturbed nerve-centre; so the subsequent interval of diminished ability to feel, answers to the interval during which the disintegrated nerve-centre is re-integrating itself. Let us observe how among sensations of all kinds we may trace conformity to this law.

An illustration is supplied by the sense of touch. If the fingers be repeatedly swept rapidly over something covered by numerous small prominences, as the papillated surface of an ordinary counterpane, a peculiar feeling of numbness in them results: the objects touched the moment after seem smoother than usual; implying that the small irregularities on them produce less vivid impressions. That the sensation of muscular tension undergoes a variation similarly caused, everyone knows. After carrying a very heavy body in the hand for some time, a small body held in the same hand appears to have lost its weight; showing that the nerve-centre which is the seat of the sensation has been, for the moment, rendered obtuse. How the gustatory faculty is exhausted for a time by a strong taste, daily experience teaches. When sugar or honey has just been eaten, things that are but slightly sweetened seem to have no sweetness. While the palate is still hot with a curry, an unflavoured dish seems insipid; and a glass of liqueur is fatal to the appreciation of a choice wine. Even more marked is that incapacity of the sense of smell caused in like manner. The intensity of the pleasurable feeling given by a rose held to the nostrils, rapidly diminishes; and when the sniffs have been continued for some time, scarcely any scent can be perceived. A few minutes' rest partially restores the impressibility; but a long interval must elapse before the odour is enjoyed as keenly as at first. This quick exhaustion, producing in such cases some disappointment, has its correlative advantage when the smells are disagreeable. Very soon these become much less perceptible; and to those living in it a stench gives scarcely any annoyance. The feelings generated by sonorous vibrations rarely show us this variation in a marked degree; being, as they commonly are, too short to leave much nervous prostration. A strong taste, or odour, or sensation of muscular tension, is due to an action on the nerves that is maintained for a considerable time; but the actions to which are due those loud sounds required to cause temporary unimpressibility, are mostly very brief. Illustrations are to be expected only in special cases; and in these we find them. The bang of a cannon is described as deafening by those who are close to the cannon when it is fired, because they are rendered for a time partially deaf to ordinary sounds. On men engaged in artillery-practice, the repeated explosions entail a dulness of hearing that lasts for hours; and this dulness of hearing becomes permanent in those who are permanently occupied in such practice. Numerous and very conclusive proofs are supplied by the feelings we receive from light. There are two classes of them: those showing us a variable sensibility to light in general, as contrasted with darkness; and those showing us a variable sensibility to each kind of light —each colour. Under the one head the reader may first be reminded of the experience that on going out of broad sunshine into a dimly-lighted place, it is impossible to discern the surrounding objects: only after a time do they become faintly visible, and a considerable interval elapses before they are seen with clearness. Disabilities similarly caused are disclosed, when, instead of acting on the retinæ as wholes, we act differently on their different parts. Hence what are called negative images. If, after gazing for some moments at an object presenting strong contrasts of light and dark parts, the eyes are turned towards a shaded space, containing nothing conspicuous, there will be perceived a transient image of the object, in which the light and dark parts are reversed. The interpretation of this fact is that those portions of each retina on which strong light had fallen, together with the answering portions of the optic centres, having undergone the most change with corresponding production of the most feeling, are the next instant less capable of undergoing change and evolving feeling than the portions on which feeble light had fallen; and hence, when they are together exposed to the same feeble light, the unexhausted parts appreciate it more than the exhausted parts, and a negative image results. The cases of the second class are the well-known phenomena of subjective complementary colours. After looking intently at a surface of bright red, an adjacent surface of white seems to have a greenish tint. The explanation is obvious. Those nervous elements changed by the rays which produce in us the sensation of redness, having been partially incapacitated, the red rays contained in the white light cause less of their appropriate effect than usual; while the blue and yellow rays causing their usual effects, and therefore relatively-predominant effects, a sensation of greenness arises.

This decrease in the susceptibility to a feeling of any kind, which immediately follows a feeling of that kind, is not a constant decrease. It is a decrease that varies greatly in degree; and from its variation we may derive further instructive evidence. Other things equal, it is small or great according to the great or small constitutional vigour. One of these disabilities lasts for a scarcely appreciable time when the vital activities are high; and lasts for a time that becomes longer and longer as the vital activities flag. Abundant proof of this is furnished by the negative images just described. In youth these are scarcely if at all to be observed: only when an extremely-vivid retinal impression has been produced, as by looking at the Sun, is the negative image perceptible. But in middle life and afterwards, especially in debilitated persons, negative images of ordinary objects are very commonly perceived, and often have considerable durations.* Feeling being the subjective correlate of that which we know objectively as nervous action, these facts are obvious corollaries from facts set down in the last chapter. We there saw that the excitement of a nerve-centre involves waste; and that restoration of the nerve-centre to a state of equal susceptibility can be effected only by repair. Hence the return of fitness for what is objectively stimulation and subjectively feeling, will vary in quickness according to the rate of repair. When the blood is rich and rapidly circulated, the partial disability will be but momentary; and, unless the sensation has been intense, will be inappreciable. But along with failing nutrition of the tissues, the disability will become marked and its duration longer. In further illustration of this, I may name the fact that negative images are most conspicuous on awaking in the morning, when the circulation is slow. The sense of hearing yields parallel evidence; though evidence of which the parallelism is not

* This change comes on so gradually that very few remark it; and the usual supposition is that negative images are much the same at all ages and in all persons. I am able, however, to give personal testimony to the contrary. When about twenty years of age, my attention was drawn by my father to a case in which the circumstances were favourable for perceiving the negative image, and in which he perceived it clearly. To me it was invisible; and I well remember his remark, that I should begin to see such images as I became older. He was right. I now see them distinctly; and, moreover, I observe that they are most distinct at times of least vigour. It is worth while inquiring how far this change affects the appreciation of the chromatic harmonies. It seems inferable that the harmonies of complementary colours become more perceptible as life advances.

immediately obvious. Persons on whom old age or debility brings deafness, frequently describe themselves as having no difficulty in hearing sounds, but as being unable to disentangle and identify words when they are indistinctly or rapidly uttered. Supposing that in such cases the nervous structures concerned suffer from faulty nutrition, we have an explanation of this peculiarity. For if each of the successive sounds entails waste of the auditory centres, and leaves them less sensitive to like sounds, it must follow that, when re-integration is slow, the like sounds immediately afterwards received will produce less than their due amounts of sensation. These defects of sensation will show themselves most in a comparative deadness to those delicate consonantal modifications by which words are mainly distinguished from one another—the utterances listened to will seem a series of vowel-sounds joined by blurred consonants. Hence the reason why persons thus affected, ask those who address them to articulate slowly and clearly. The confusion of impressions produced by rapid speech on auditory centres thus debilitated, may be conceived by supposing debilitated optic centres to be similarly treated. If a person in whom the negative images are strong, has a series of objects passed before his eyes so fast that he can have only a momentary glance at each (to parallel the momentary opportunity which the ears have of identifying each successive articulation); then it will manifestly happen that the negative image of each object will interfere with, and confuse, the positive image of the next; and such a person will therefore not identify the successive objects so readily as one whose optic centres are repaired with normal speed. As confirming the belief that this defect of hearing is so caused, I may add that it frequently co-exists with the defect of vision to which I have compared it; and also that the one, like the other, is most marked early in the day, and is diminished by whatever invigorates the circulation.

§ 46. Another class of correlations demands a passing notice. Up to this point, the feelings considered have been subjective aspects of those changes which objectively are nervous stimulations. We have now to consider certain other feelings which are the inner faces of what on their outer faces are nervous discharges. Having traced pretty fully the concomitance of sentient states and *recipio-motor* acts, it will suffice to trace briefly the concomitance of sentient states and *dirigo-motor* acts.

Certain inferior *dirigo-motor* acts are unconscious; but omitting these, the law is that with each muscular contraction there goes a sensation more or less definite. This is not a sensation indirectly produced through the nerves proceeding inwards from the skin, some of which are nearly always disturbed by each bodily motion; but it is a sensation directly produced, either by the discharge itself or by the state of the muscle or muscles excited. It is most clearly distinguished when, without touching anything and without moving, a leg or arm is held out at right angles to the body.

Vague as are feelings of this class in comparison with most feelings accompanying nervous stimulations, and much less numerous as are the varieties of quality among them, they are nevertheless so far definite and different that we can, to a certain extent, recognize the separate feeling belonging to each separate contraction. We are aware without looking at it, and without touching anything with it, which finger has been bent by the discharge sent to its flexor muscles; and, by the particular combination of feelings accompanying the act, the placing of a limb in a given attitude is present to consciousness without aid from the eyes or hands. I say we can to a certain extent recognize the changes we thus set up; because the differences among the sensations of muscular tension soon lose much of their distinctness. It is a curious fact that when a limb has been held for some time in any position, especially if the position is one involving but little strain, the subjective state associated with the nervous discharge to its muscles, becomes so indefinite that the attitude of the limb is unknown, if there does not happen to be a recollection of it.

Besides the connection between what we know objectively as a particular motor act, and subjectively as a particular feeling of muscular tension, there is a connection between the accompanying motor excitement propagated throughout the muscular system, and a certain diffused feeling of which it is the seat. How along with each special nervous discharge there goes a general nervous discharge, we saw in the last chapter; and here we recur to the relation only to observe that there is a parallel relation between the concomitant states of consciousness. Thus the vivid sensation caused by putting the foot into scalding water, does not lead only to the muscular contractions and muscular feelings which accompany the sudden withdrawal of the leg, but also to contractions of countless other muscles throughout the body, and a feeling called a shock or start.

Nor are these subjective states, special and general, that accompany special and general discharges to the muscles, the only subjective states that accompany discharges. As before pointed out, the vascular system and the alimentary system receive their shares of each discharge—very appreciable when it is intense, and probably in no case wanting; and these, too, present inner aspects to consciousness. Sometimes, indeed, the feelings that go along with discharges into the vaso-motor and sympathetic nerves, are the predominant ones; as instance the thrill diffused through the body by certain acute creaking sounds said to "set the teeth on edge;" or the nausea produced by particular kinds of disagreeable odours.

§ 47. Are these correlations between nervous actions and the concomitant feelings quantitative? Is there such connection between a physical change in the nervous system and the psychical change accompanying it, that we may regard the one as an equivalent of the other, in the same sense as we regard so much heat as the equivalent of so much motion? The reader will perhaps expect an affirmative answer; but if an affirmative answer is to be given, it must be given in a greatly-qualified form.

On remembering that many nervous actions are always unconscious; on also remembering that various objective states of the nervous system which have associated subjective states early in life, cease to have them later in life; and on remembering, further, that at the same period of life a change set up in an afferent nerve may cause an appreciable feeling, or may not cause it, according as the attention is free or occupied; we shall see that the connection between feelings and nervous changes is conditioned in a very complex way, and that if they are quantitatively related it can be only within the narrow limits implied by the complex conditions. If between a purely voluntary act and a purely automatic act there are gradations—if, at the one extreme, feeling is a conspicuous accompaniment, and, at the other extreme, ceases to be an accompaniment; then, clearly, in the intermediate phases the amount of feeling must bear a varying ratio to the amount of nervous change which the act implies. Again, if we assume that what is present to consciousness as a sensation of given strength, is the correlate of a proportionate molecular disturbance in all the nervous structures concerned, how shall we interpret the sensations distinguished as subjective? In sundry abnormal states, strong feelings of cold or heat are felt throughout the body, though its actual temperature has remained unaltered. As in any case of this kind the total nervous change cannot have been the same as if the skin had fallen or risen in temperature to the degree ordinarily required to produce the feeling, we cannot say that there is a quantitative equivalence between the amount of nervous change and the amount of feeling. The disagreeable smell which, on the approach of a fit, the epileptic patient frequently complains of, affords a yet better illustration. Here the outer ends of the afferent nerves being undisturbed, and only certain central structures irritated, the quantity of nervous action is not the same as if the sensation had been generated by an actual smell. More conspicuously still do we see the variability of this relation, when we compare the feelings called efforts with the discharges and muscular strains produced by them under different conditions. If the psychical force known as effort were transformable into a constant quantity of physical force, then, in any two cases, equal efforts should produce equal contractions. But they do not. Great exertion in a child fails to evolve from its motor organs the dynamic effect which a small exertion evolves from those of a man. Any one who is fatigued finds that an intenser feeling of strain is requisite to generate a given degree of muscular tension, than when he is fresh. And those prostrated by illness show us that immense expenditures of feeling are needed to perform acts which, during health, need scarcely appreciable expenditures of feeling. Doubtless these differences are partly due to differences in the muscles; which, when undeveloped or when wasted, are excited to smaller amounts of tension by equal amounts of discharge. But we must regard them as partly due to the imperfect development, or the worn state, of the intermediate motor centres and efferent nerves, in which a given feeling excites a smaller molecular disturbance than when they are finished in structure and in complete repair—a conclusion enforced by the familiar experience that purely nervous acts, as those of thought, require unusual efforts when the brain is tired.

This variability of the quantitative relation between nervous actions and psychical states, is equally seen when we limit our comparisons to those nervous actions and psychical states which occur in the same individual under the same bodily conditions. To show that unlike but equally intense sensations may be produced by peripheral disturbances widely unlike in their amounts, providing they arise in different external sense-organs, is scarcely possible without comparing the amounts of the incident forces; and this we cannot properly do, since we are here confining our attention to correlations within the organism. We are similarly debarred from going at length into the quantitative contrasts between the muscular tensions produced by the same feeling of effort, according as the muscles excited are large or small; for we cannot well establish these contrasts without measuring the muscular tensions by the external actions they are equivalent to. There is, however, one class of appropriate cases—those in which irritations arising within the organism, set up sensations that cause undirected motor discharges. Violent toothache, for example, is due to waves of molecular change sent through one or two minute afferent nerve-fibres; but the bodily contortions show us that the feeling so produced, suffices to send waves of molecular change through various large bundles of efferent nerve-fibres, and to contract numerous muscles with much force. To which of these disturbances, centripetal or centrifugal, is the feeling equivalent? We cannot say to both, for one is many times the other in amount; and we have no reason to say that it is equivalent to one rather than to the other: the rational inference being that it is not equivalent to either.

To understand the real relations between objective and subjective changes in the nervous system, we need but to recall certain of the conclusions reached in preceding chapters. The essential principle of nervous organization we have seen to be that the small amounts of motion received, liberate larger amounts, and these again still larger amounts. A disturbance in the end of an afferent nerve is multiplied as it traverses the nerve, and the degree of multiplication varies with the length of the nerve; it is much more multiplied in the first ganglion reached, and increases further in traversing the centripetal nerve; it is again multiplied in the superior centre, to be afterwards augmented in its subsequent centrifugal course; and it is once more multiplied, probably in a far greater degree, in the contractile substance of the excited muscles. Hence the accompanying feeling, which is the subjective aspect of this disturbance at one of its intermediate stages, can be a quantitative equivalent neither of the initial nervous change nor of the terminal nervous change. Moreover, since the multiplication varies in degree, being much greater in the organs of the higher senses than in those of the lower, it follows that the ratio between the amount of feeling and the amount of initial change is far from constant; and the evidence clearly indicates a like inconstancy of the ratio between the amount of feeling and the amount of terminal change, according as one or other muscle or set of muscles is made to act.

How then can there be any quantitative relation, it will be asked. If there is no equivalence between a disturbance set up at the periphery and the produced feeling, and no equivalence between the produced feeling and the motor discharge that follows—if the feeling does not even bear the same ratio to either the initial or the terminal nervous change in different cases; what quantitative relation can there be? The reply is simple. There is a quantitative relation between nervous change and feeling when all other things remain the same; and there is a quantitative relation between feeling and resulting contraction when all other things remain the same. Supposing every condition to continue unaltered, then the stimulus conveyed through a given nerve to a given centre, will evoke a feeling that increases and decreases in something like the same proportion as the stimulus increases and decreases; and, supposing a given muscle to be contracted, then the amount of its contraction will bear a tolerably constant ratio to the feeling of effort that accompanies the contraction of it. The nature of these correlations may best be expressed by numbers. If, coming through a given afferent nerve, a disturbance represented by 1 generates a feeling represented by 5, then disturbance 2 will generate feeling 10, and disturbance 5 feeling 25; and if, acting through a given efferent nerve, feeling 5 results in muscular tension 60, feeling 10 will result in muscular tension 120. But to complete this numerical expression of the facts we must suppose these ratios to vary with every set of afferent nerves and every set of efferent nerves. If we say that 1 to 5 represents the ratio of disturbance to feeling in the sense of touch, then to represent it in the sense of hearing will need, say, 1 to 100, and in the sense of sight perhaps 1 to 1,000; and similarly with the ratios throughout the motor apparatus, according as the muscles are large or small.

In brief, then, the quantitative correlation of feeling and nervous change, holds true only within narrow limits. We have good reason to conclude that at the particular place in a superior nervous centre where, in some mysterious way, an objective change or nervous action causes a subjective change or feeling, there exists a quantitative equivalence between the two: the amount of sensation is proportionate to the amount of molecular transformation that takes place in the vesicular substance affected. But there is no fixed, or even approximate, quantitative relation between this amount of molecular transformation in the sentient centre, and the peripheral disturbance originally causing it, or the disturbance of the motor apparatus which it may eventually cause.

§ 48. The feelings called sensations have alone been considered thus far; leaving out of view the feelings distinguished as emotions. Much less definite as they are, and not capable of being made at will the objects of observation and experiment, the emotions are more difficult to deal with. But having discerned certain general laws to which the simpler feelings conform, we may now ask whether, so far as we can see, they are conformed to by the more complex feelings. We shall find that they are.

The conditions essential to the one are essential to the other. Emotions, like sensations, may be increased or decreased in intensity by altering either the quantity or the quality of the blood. That general abundance of blood is a cause of emotional exaltation, though tolerably certain, is not easily proved; but there is sufficient evidence of the converse fact that, other things equal, depletion is a cause of apathy. The effect of local abundance of blood is undoubted: there is no question that, within limits, the amount of emotion varies as the amount of blood supplied to the great nervous centres. That nervous stimulants intensify the emotions, or, as we say, raise the spirits, is even more manifest than that they make the sensations keener. And it is a familiar truth that sedatives diminish what is distinguished as moral pain, in the same way that they diminish pain arising in the trunk or limbs.

That a feeling lasts an appreciable time, is no less true of an emotion than of a sensation: indeed the persistence is relatively conspicuous. The state of consciousness produced by a flash of lightning, is so brief as to seem instantaneous: only by the help of artificial tests are sensations of this kind found to have measurable durations. But no such tests are needed to prove that emotions continue through appreciable periods. Even a simple emotion, as of anger or fear, does not reach its full strength the moment the cause presents itself; and after the cause is removed it takes some time to die away. When hereafter we deal with the origin of emotions, and recognize the fact that they are of far more involved natures than sensations, and imply the co-operation of extremely intricate nervous structures, we shall understand how this greater duration is necessitated.

That an emotion, like a sensation, leaves behind it a temporary incapacity, is also true; and as the emotion produced by a momentary cause lasts longer than a sensation produced by a momentary cause, so does the partial incapacity for a like emotion last longer than the partial incapacity for a like sensation. Passions of all kinds come in gushes or bursts. That they often continue for hours and days, is true; but they are never uniform throughout hours and days. Be it in grief, or joy, or tenderness, there is always a succession of rises and falls of intensity—a paroxysm of violent feeling with an interval of feeling less violent, followed by another paroxysm. And then, after a succession of these comparatively-quick alternations, there comes a calm—a period during which the waves of emotion are feebler: succeeded, it may be, by another series of stronger waves. As in the case of the sensations so in the case of the emotions, this follows from the fact that what is objectively a nervous action and subjectively a feeling, involves waste of the nervous structures concerned. The centres which are the seats of emotions undergo disintegration in the genesis of emotions; and, other things remaining equal, thereupon become less capable of generating emotions until they are re-integrated. I say, other things remaining equal, because the rise of an emotion brings blood to the parts implicated, and so long as the afflux is increasing the intensity of the emotion may increase, notwithstanding the waste that has taken place; but the several conditions on which activity depends having become constant, a diminished capacity for emotion inevitably follows each gush of emotion.

That daily rises and falls of strength, consequent on daily periodicities of waste and repair, occur in the emotions as in the sensations, is also tolerably manifest. Cultivated people, mostly leading lives that exercise their brains too much and their muscles too little, and placed in social conditions that commonly bring the strongest excitements towards the close of the day, are subject to an abnormal periodicity. But those whose lives conform best to the laws of health, exhibit early in the day a general joyousness and emotional vivacity greater than they do towards its close, when approaching sleepiness is shown by a flagging interest in the things and actions around.

These complex feelings that are centrally initiated are also like the simple feelings that are peripherally initiated, in having general discharges as well as special discharges: indeed their general discharges are the more conspicuous of the two. A sensation is often visibly followed only by local movement: unless very strong its effect on the organism as a whole is unobtrusive. But an emotion, besides the more obvious changes it works in the muscles of the face, habitually works changes, external and internal, throughout the body at large. The respiration, the circulation, the digestion, as well as the attitudes and movements, are influenced by it even when moderate; and everyone knows how strong passions, pleasurable or painful, profoundly disturb the whole system.

§49. Nothing has yet been said about the most conspicuous and most important distinction existing among the feelings. Every feeling, besides its minor variations of intensity, exists under two strongly-contrasted degrees of intensity. There is a vivid form of it which we call an actual feeling, and there is a faint form of it which we call an ideal feeling. What is the nature of this difference as interpreted from our present stand-point?

When studying nerve-structure, we saw that, in addition to connections formed by grey matter between the central ends of afferent and efferent nerves, these have connections with centripetal and commissural nerves, which are again connected with more distant nerves. And when studying nerve-function, we saw that a disturbance set up by an afferent nerve in its ganglion, does not affect exclusively the efferent nerve, but that part of it, conveyed through centripetal and commissural nerves, affects other centres, and these again others, until it has reverberated throughout the entire nervous system. What follows? These reverberations are feeble disturbances. And every centre, liable as it is to be strongly disturbed through its afferent or centripetal nerve, is liable also to be feebly disturbed by these reverberations arriving through other nerves. What then must happen with each of the *libero-motor* elements composing those higher centres in which nervous changes become changes of consciousness? When it is affected through the direct and fully-opened route, by that peripheral impression to which it stands organically related, it evolves much molecular motion, becomes an active propagator of disturbances throughout the nervous system, and is the seat of what we call a real feeling; but when it is affected by these secondary waves diffused from other strongly excited parts, it becomes, as compared with them (or with itself under the previous condition) a generator of but little molecular motion, and is the seat of that faint feeling which we distinguish as ideal. In brief, those vivid states of consciousness which we know as sensations, accompany direct and therefore strong excitations of nerve-centres; while the faint states of consciousness which we know as remembered sensations, or ideas of sensations, accompany indirect, and therefore weak, excitations of the same nerve-centres.

That the contrast of intensity between the effects of direct and indirect excitations, though it holds generally, does not hold without exception, is a fact quite reconcilable with this interpretation. For, on the one hand, a direct excitation may be very feeble; while, on the other hand, through a concurrence of diffused disturbances, an indirect excitation may rise to considerable strength. Hence, occasionally, an ideal feeling will become almost or quite equal in vividness to a real feeling. Especially may this happen when the nerve-centre concerned is surcharged with blood; since a small disturbance may then set up in it an amount of change equal to that which a great disturbance produces when only the ordinary quantity of blood is present. And it is a matter of observation that congested nerve-centres are those in which indirectly-excited feelings reach an intensity scarcely less than that of directly-excited feelings.

When we pass from the feelings called sensations, of which the strong forms are peripherally initiated, to the feelings called emotions, of which the strong forms are centrally initiated, we find the difference between the strong and the weak forms by no means so great; so that, in fact, ideal emotion passes into actual emotion without any line of demarcation. Obviously this is what might be anticipated. For whether ideal or actual, emotion is an accompaniment of an indirect excitation: it is not an immediate result of peripheral impressions, either simple or combined; but a mediate or remote result of them. Hence, all emotions, vivid and faint, being the subjective aspects of objective nervous changes that are produced indirectly, are distinguishable only according to the degree of indirectness of the excitation, and this admits of insensible gradations.

§ 50. One more general truth must be set down to complete the outline. The foregoing inferences joined with some contained in the last chapter, introduce us to it.

In §§ 36, 37, it was pointed out that nerve-centres disintegrated by action, are perpetually re-integrating themselves, and again becoming fit for action. We saw that repair partially makes up for waste from instant to instant, and that the arrears of repair are made up daily during that period of quiescence when waste almost ceases. We further saw that the restoration of a nerve-centre to its state of integrity, is not only the filling up of its quantum of decomposable matter, but is also the replacing of molecules most exposed to disturbance, and consequently the production of a comparatively-unstable state. And we saw how, after a period of profound repose, there thus arises a condition of the nerve-centres such that very slight stimuli cause nervous discharges.

This law applies not generally only, but specially to each nerve-centre and each of its component parts. In proportion as any part of a nerve-centre has been for a long time unused—in proportion, that is, as repair of it has gone on day after day and night after night unhindered by appreciable waste, it must be brought to a state of more than ordinary instability—a state of excessive readiness to decompose and discharge. What must happen? In common with all other parts, it is exposed to these reverberations which from instant to instant fill the nervous system. Its extreme instability must render it unusually sensitive to these reverberations—unusually ready to undergo change, to yield up molecular motion, and to become the seat of the concomitant ideal feeling. Besides a great liability to the ideal feeling this same condition must entail a great strength of it; and so while the instability continues, a strong ideal feeling will be perpetually aroused. As, however, the nerve-centre in which such secondary molecular changes and accompanying ideal feelings are thus set up, is somewhat wasted by them, it follows that after they have gone on for a considerable period the instability of the centre will be diminished: it will no longer be so easily decomposed by indirect disturbances, and the feeling will not be produced.

Here we have the interpretation of what are called *desires*. Desires are ideal feelings that arise when the real feelings to which they correspond have not been experienced for some time. They are then liable to be excited by various of the indirect disturbances reflected from part to part of the nervous system. They are usually vivid and persistent in proportion to the previous period of rest—more vivid and more persistent than ideal feelings of the same kind under ordinary conditions. But after a prolonged period during which they continue to arise and almost monopolize consciousness, they become feebler and finally die away.

§ 51. Such are the leading truths of Æstho-Physiology, set forth with as much fulness as is here requisite. Sensation and emotion in their relations to nervous action, have been dealt with generally; and whatever has been said of special sensations and special emotions has been said merely to illustrate a law which holds among all the rest. The concomitants, subjective and objective, of each particular kind of sensation and each particular kind of emotion, I here pass over. They may be studied to great advantage in the works of Professor Bain on *The Senses and the Intellect*, and *The Emotions and the Will;* in which he has given an elaborate account of the connection between each particular feeling, simple or complex, and its various physical accompaniments. To these works I must commend the reader who wishes to trace out these minor correlations. As data for the present treatise, the only facts needful to be carried with us are those set forth in the preceding sections. They may be summed up thus.

Feeling of whatever kind is directly known by each person in no other place than his own consciousness. That feelings exist in the world beyond consciousness, is a belief reached only through an involved combination of inferences. That alike in human and inferior beings, feelings are accompaniments of changes in the peculiar structure known as the nervous system, is also an indirectly-established belief. And that the feelings alone cognizable by any individual are products of the action of his own nervous system, which he has never seen and on which he can try no experiments, is a belief only to be arrived at through a further chain of reasoning. Nevertheless, the evidence, though so indirect, is so extensive, so varied, and so congruous, that we may accept the conclusion without hesitation.

The conclusion having been accepted—provisionally if not permanently—its validity is shown by leading us to anticipate truly, in one set of cases after another, the particular subjective phenomena that accompany particular objective phenomena. We have seen that the several circumstances which facilitate or hinder nervous action, are also circumstances which facilitate or hinder feeling. We have seen that as nervous action occupies appreciable time, so feeling occupies appreciable time. We have seen that each feeling leaves a partial incapacity for a like feeling as each nervous action leaves a partial incapacity for a like nervous action. We have seen that, other things equal, the intensities of feelings vary as the intensities of the correlative nervous actions. We have seen that the difference between direct and indirect nervous disturbances, corresponds to the difference between the vivid feelings we call real and the faint feelings we call ideal. And we have seen that certain more special objective phenomena which nervous actions present, have answering subjective phenomena in the forms of feeling we distinguish as desires.

Thus, impossible as it is to get immediate proof that feeling and nervous action are the inner and outer faces of the same change, yet the hypothesis that they are so harmonizes with all the observed facts; and, as elsewhere shown (*First Principles*, § 40) no other verification is possible for us than that which results from the establishment of complete congruity among our experiences.

CHAPTER VII.

THE SCOPE OF PSYCHOLOGY.

§ 52. We may now enter on our special topic. Thus far we have been occupied with the data of Psychology, and not with Psychology properly so-called. Here leaving the foundations we pass to the superstructure.

Not a few readers will be surprised by the assertion that none of the truths we have been contemplating are psychological truths. Since the anatomy and physiology of the nervous system have occupied so much attention, and since it has been growing manifest that there is a fundamental connection between nervous changes and psychical states, there has arisen a confusion between the phenomena which underlie Psychology and the phenomena of Psychology itself. In reality, all the facts ascertained by those who have made nerve-structure and nerve-function their studies, are facts of a simpler order than those rightly termed psychological; though they are facts entering into the composition of psychological facts.

Most will admit without hesitation that the first five chapters of this part consist of propositions which are exclusively morphological and physiological. In them the structure of the nervous system, its functions, the conditions to its action, &c., have been dealt with purely as physical phenomena—phenomena as purely physical as the absorption of nutriment or the circulation of the blood. Whatever implications may have arisen from the use of words that carry with them indirect meanings, the direct meanings of all the propositions set down have nowhere implied consciousness or feeling; and, ignoring consciousness or feeling, they have left out that which is tacitly or avowedly contained in every proposition of Psychology.

It will probably be thought, however, that at any rate truths belonging to Psychology proper are to be found in the last chapter. Dealing as the last chapter does with the connections between nervous changes and feelings, it necessarily becomes, by including a psychical element, a part of psychical science. To this the rejoinder is that, though it can scarcely be excluded absolutely from the body of this science, yet it does not strictly fall within that body. Æstho-physiology has a position that is entirely unique. It belongs neither to the objective world nor the subjective world; but taking a term from each, occupies itself with the correlation of the two. It may with as much propriety be included in the domain of physical science as in the domain of psychical science; and must be left where it stands, as the link between them.

Perhaps this explanation will increase rather than decrease the surprise produced by the assertion that was to be justified. To clear up the confusion, we must examine more carefully the distinction between the truths which are strictly psychological and those which merely enter into the composition of psychological truths.

§ 53. Throughout the preceding chapters, including even the last, every proposition set down has expressed some relation of phenomena occurring within the limits of the organism. The subject-matter has been the character of a structure; or the effect which a disturbance set up in one place has in causing motion in another; or the connection between the physical state of the whole or a part of the organism, and some general or local nervous process; on the variable intensity of an action in a nerve-centre as determined by a preceding like action; or the interdependence of internal physical changes and internal psychical changes. That is to say, the attention has everywhere been directed exclusively to co-existences and sequences of which the body alone is the sphere. Distinct or tacit reference has, indeed, frequently been made to some external force. Either a disturbing agent lying beyond the limits of the organism has been referred to in general terms, or, for illustration's sake, this or the other kind of disturbing agent has been named. But such references, vague or distinct, have been made merely because it was needful to suppose something by which an organic change was set up; not because this something had to be included in the proposition set down, which in every case formulated an internal relation only. The entanglement of phenomena is such, that we can never cut off absolutely from all others the particular phenomena we are dealing with; but, because we presuppose these other phenomena, it does not follow that the science to which they pertain forms part of the science with which we are specially occupied. For instance, it is impossible to describe, or think of, a chemical experiment that discloses some chemical relation, without making distinct or tacit references to physical relations—the pouring and mixture of liquids, the ascent of bubbles of disengaged gas, the falling of a precipitate; but it is not therefore held that we are including physics in our chemistry. Similarly, it must be admitted that though the foregoing chapters have tacitly assumed environing forces, yet this assumption has been simply incidental to the study of internal co-existences and sequences.

Now so long as we state facts of which all the terms lie within the organism, our facts are morphological or physiological and in no degree psychological. Even though the relation with which we are dealing is that between a nervous change and a feeling, it is still not a psychological relation so long as the feeling is regarded merely as connected with the nervous change, and not as connected with some existence lying outside the organism. As certainly as the man who demonstrates by dissection the articulations of the bones, and the man who, by a sphygmograph, delineates the varying motions of the heart, are respectively studying morphology and physiology; so certainly is the man who examines nervous structure and experiments on nervous function, a student of these same sciences, if he considers the inner correlations only and does not simultaneously consider the answering outer correlations.

For that which distinguishes Psychology from the sciences on which it rests, is, that each of its propositions takes account both of the connected internal phenomena and of the connected external phenomena to which they refer. In a physiological proposition an inner relation is the essential subject of thought; but in a psychological proposition an outer relation is joined with it as a co-essential subject of thought. A relation in the environment rises into co-ordinate importance with a relation in the organism. The thing contemplated is now a totally different thing. It is not the connection between the internal phenomena, nor is it the connection between the external phenomena; but it is *the connection between these two connections.* A psychological proposition is necessarily compounded of two propositions, of which one concerns the subject and the other concerns the object; and cannot be expressed without the four terms which these two propositions imply. The distinction may be best explained by symbols. Suppose that A and B are two related manifestations in the environment—say, the colour and taste of a fruit; then, so long as we contemplate their relation by itself, or as associated with other external phenomena, we are occupied with a portion of physical science. Now suppose that *a* and *b* are the sensations produced in the organism by this peculiar light which the fruit reflects, and by the chemical action of its juice on the palate; then, so long as we study the action of the light on the retina and optic centres, and consider how the juice sets up in other centres a nervous change known as sweetness, we are occupied with facts belonging to the sciences of Physiology and Æstho-physiology. But we pass into the domain of Psychology the moment we inquire how there comes to exist within the organism a relation between *a* and *b* that in some way or other corresponds to the relation between A and B. Psychology is exclusively concerned with this connection between (A B) and (*a b*)—has to investigate its nature, its origin, its meaning, &c.

A moment's introspection will now make it clear to the reader, that he cannot frame any psychological conception without thus looking at internal co-existences and sequences in their adjustments to external co-existences and sequences. If he studies the simplest act of perception, as that of localizing a touch in some part of his skin, the indispensable terms of his inquiry are:—on the one hand a thing (1) and a position (2), both of which he regards as objective; and on the other hand a sensation (3), and a state of consciousness constituting his apprehension of position (4), both of which he regards as subjective. Again, to cite an example from the opposite extreme, if he takes for his problem one of his involved sentiments, as that of justice, he cannot represent to himself this sentiment, or give any meaning to its name, without calling to mind actions and relations supposed to exist in the environment: neither this nor any other emotion can be aroused in consciousness even vaguely, without positing something beyond consciousness to which it refers. And when, instead of studying Psychology subjectively, he studies it objectively in the acts of other beings, he similarly finds himself incapable of stirring a step without thinking of inner correlations in their references to outer correlations.

§ 54. It is contended by some that Psychology is a part of Biology, and should be merged in it; and those who hold this view will possibly answer the above argument by saying that in many cases the non-psychological part of Biology also takes into account phenomena in the environment, and even definite connections among these phenomena. The life of every organism is a continuous adaptation of its inner actions to outer actions; and a complete interpretation of the inner actions involves recognition of the outer actions. The annual production of leaves, flowers, and seeds by plants, is adjusted to the annual changes of the seasons; and there is in animals an adjustment between external changes in temperature and abundance, and internal production of ova. Moreover, there are many special relations of structure and function in plants and animals, that have reference to special relations of structure and function in surrounding plants and animals: instance those arrangements of the sexual organs that fit particular phænogams for being fertilized by the particular insects that visit them.

But true as is this conception of Life (and having based the *Principles of Biology* on it I am not likely to question or to undervalue it), I nevertheless hold the distinction above drawn to be substantially valid. For throughout Biology proper, the environment and its correlated phenomena are either but tacitly recognized, or, if overtly and definitely recognized, are so but occasionally; while the organism and its correlated phenomena practically monopolize the attention. But in Psychology, the correlated phenomena of the environment are at every step avowedly and distinctly recognized; and are as essential to every psychological idea as are the correlated phenomena of the organism. Let us observe the contrast as exemplified. We study digestion. Digestion implies food. Food implies neighbouring plants or animals. But this implication scarcely enters into our study of digestion, unless we ask the quite special question—how the digestive organs become fitted to the materials they have to act upon? Again, when we interpret respiration we take for granted a surrounding oxygenated medium. And yet to show how far the two may be separated, we need only remember that the phenomena of respiration may be very well traced out in one who breathes a bladder of gas artificially obtained from peroxide of manganese or chlorate of potash. Once more, if, in following out the life-history of a plant, we have to note the adaptation of its hooked seeds to the woolly fleece of the animal which accidentally carries them off and disperses them, this distinct reference to specially-connected phenomena in the environment, occurs either but once in an account of the plant's life, or only at long intervals. In fact, we may say that the great mass of purely biological phenomena may be displayed for some time by an organism detached from its medium, as by a fish out of water. Now observe how different it is with psychological phenomena. We cannot explain a single act of a fish as it moves about in the water, without taking into account its relations to neighbouring objects distinguished by specially-related attributes. The instinctive proceedings of the insect, equally with those which in higher creatures we call intelligent, we are unable even to express without referring to things around.

In brief, then, the propositions of Biology, when they imply the environment at all, imply almost exclusively its few general and constant phenomena, which, because of their generality and constancy, may be left out of consideration; whereas the propositions of Psychology refer to its multitudinous, special, and ever-varying phenomena, which, because of their speciality and changeability, cannot be left out of consideration.

§ 55. The admission that Psychology is not demarcated from Biology by a sharp line, will perhaps be construed into the admission that it cannot rightly be regarded as a distinct science. But those who so construe the admission, misconceive the natures of the relations among the sciences. They assume that there exist objectively those clear separations which the needs of classification lead us to make subjectively. Whereas the fact is, that beyond the divisions between the three fundamental orders of the sciences, Abstract, Abstract-concrete, and Concrete, there exist objectively no clear separations at all: there are only different groups of phenomena broadly contrasted but shading off one into another. To those who accept the doctrine of Evolution, this scarcely needs saying; for Evolution being a universal process, one and continuous throughout all forms of existence, there can be no break—no change from one group of concrete phenomena to another without a bridge of intermediate phenomena. It will be well here, however, to show by illustrations that the simpler concrete sciences are separable from one another only in the same way that Psychology is separable from Biology.

Astronomy and Geology are regarded as distinct. But Geology is nothing more than a chapter continuing in detail one part of a history that was once wholly astronomic; and even now, many of its leading facts belong as much to the older part of the history as to the younger. Not only do we trace back the Earth to a time when its astronomic attributes were uncomplicated by those geologic ones that have gradually arisen as it cooled; not only in the solar heat, causing the aërial, marine, and fluvial currents which work most geologic changes, are we compelled to recognize an astronomic force; but in the tidal wave we have a phenomenon as much astronomic as geologic, and as much geologic as astronomic. Even he who arbitrarily excludes from astronomy everything but the molar motions throughout the Solar System (so ignoring the radiant light and heat by which alone the Sun and planets are known to us) does not escape this difficulty;

for the motion of the tidal wave is a molar motion generated by forces such as generate all other molar motions exhibited by the Solar System; and yet it is at the same time a motion of matter on the Earth's surface, not distinguishable from those other motions of matter which constitute geological changes, many of which, indeed, are concomitants of it. The separation between Biology and Geology once seemed impassable; and to many seems so now. But every day brings new reasons for believing that the one group of phenomena has grown out of the other. Organisms are highly-differentiated portions of the matter forming the Earth's crust and its gaseous envelope; and their differentiation from the rest has arisen, like other differentiations, by degrees. The chasm between the inorganic and the organic is being filled up. On the one hand, some four or five thousand compounds once regarded as exclusively organic, have now been produced artificially from inorganic matter; and chemists do not doubt their ability so to produce the highest forms of organic matter. On the other hand, the microscope has traced down organisms to simpler and simpler forms until, in the *Protogenes* of Professor Haeckel, there has been reached a type distinguishable from a fragment of albumen only by its finely-granular character.

Thus the distinction between Biology and Psychology has the same justification as the distinctions between the concrete sciences below them. Theoretically, all the concrete sciences are adjoining tracts of one science, which has for its subject-matter, the continuous transformation which the Universe undergoes. Practically, however, they are distinguishable as successively more specialized parts of the total science—parts further specialized by the introduction of additional factors. The Astronomy of the Solar System is a specialized part of that general Astronomy which includes our whole Sidereal System; and becomes specialized by taking into account the revolutions and rotations of planets and satellites. Geology (or rather Geogeny let us call it, that we may include all those mineralogical and meteorological changes which the word Geology, as now used, recognizes but tacitly) is a specialized part of this special Astronomy; and becomes specialized by joining with the effects of the Earth's molar motions, the effects of continuous decrease in its internal molecular motion, and the effects of the molecular motion radiated from the Sun. Biology is a specialized part of Geogeny, dealing with peculiar aggregates of peculiar chemical compounds formed of the Earth's superficial elements—aggregates which, while exposed to these same general forces molar and molecular, also exert certain general actions and reactions on one another. And Psychology is a specialized part of Biology, limited in its application to the higher division of these peculiar aggregates, and occupying itself exclusively with those special actions and reactions which they display, from instant to instant, in their converse with the special objects, animate and inanimate, amid which they move.

But this introduction of additional factors, which differentiates each more special science from the more general science including it, fails in every case to differentiate it absolutely; because the introduction of the additional factors is gradual. It is so not with the Concrete Sciences alone, but even with the Abstract-concrete Sciences, which at first sight seem sharply demarcated; as, for instance, Physics and Chemistry. Physics, dealing with changes in the distribution of matter and motion considered apart from unlikenesses of quality in the matter, is obliged to include in its inquiries all the molecular integrations and disintegrations caused by alterations of temperature—the meltings and evaporations which increase of heat produces, as well as the condensations and crystallizations which follow decrease of heat. Among other molecular transformations resulting from losses and gains of molecular motion, are those known as allotropic—transformations which, without appreciably altering the degrees of integration, leave the molecules so re-arranged that they exhibit new properties of the order we call chemical; as is shown by their changed affinities for the molecules of other substances, and by their changed effects on our nerves of sense. Must we class such molecular transformations as physical phenomena, because in each case the molecules concerned are all of one kind? If so, what are we to say of isomeric transformations, which all chemists recognize as of essentially the same nature? In these, molecules of different kinds are concerned. And if, because they show us a re-distribution of heterogeneous molecules instead of homogeneous ones, we put them in the category of chemical phenomena, we arbitrarily dissociate two fundamentally-similar classes of facts. Perhaps it will be replied that in isomeric transformations the molecules *are* homogeneous, relatively to the re-distribution they undergo; that each of them, retaining its individuality unchanged, comports itself towards the rest as though it were a simple molecule; that nothing more takes place than a re-grouping of these unchanged molecules; and that there is thus an absence of what constitutes a truly chemical change—union or disunion of unlike molecules. The reply is plausible, but it is easily disposed of. For there are transformations of this nature in which such unions and disunions occur. A colloid compound in passing from one of its isomeric forms to another, very generally parts with some of its contained water, or takes up additional water. Does this make the change a chemical one? Then we must relegate to the domain of Physics that isomerism which is not accompanied by loss or gain of water, and include in the domain of Chemistry that isomerism which is so accompanied—a very artificial disunion of the sciences, to which I think neither Physicists nor Chemists will agree. Nevertheless, undecided as is the line which separates them, we are not prevented from recognizing the broad distinction between Molecular Physics and Chemistry. The new factor which differentiates Chemistry from Molecular Physics, is the heterogeneity of the molecules with whose re-distributions it deals. And the contrast hence resulting is too strongly marked to be obliterated by transitional cases.

In this way it is, then, that the conspicuous presence of additional factors differentiates Psychology from Biology proper; although in Biology proper these factors make an occasional appearance. The contrast between the two is no more destroyed by such community as exists, than is the contrast between night and day destroyed by the occurrence of a dawn which belongs as much to one as to the other.

§ 56. A far more radical distinction remains to be drawn. While, under its objective aspect, Psychology is to be classed as one of the concrete sciences which successively decrease in scope as they increase in speciality; under its subjective aspect, Psychology is a totally unique science, independent of, and antithetically opposed to, all other sciences whatever. The thoughts and feelings which constitute a consciousness, and are absolutely inaccessible to any but the possessor of that consciousness, form an existence that has no place among the existences with which the rest of the sciences deal. Though accumulated observations and experiments have led us by a very indirect series of inferences (§ 41) to the belief that mind and nervous action are the subjective and objective faces of the same thing, we remain utterly incapable of seeing, and even of imagining, how the two are related. Mind still continues to us a something without any kinship to other things; and from the science which discovers by introspection the laws of this something, there is no passage by transitional steps to the sciences which discover the laws of these other things.

Following M. Comte, there are a few who assert that a subjective Psychology is impossible; and to such the above paragraph will, I suppose, be meaningless. But whoever recognizes a subjective Psychology, and admits, as he must, that without it there can be no objective Psychology, thereupon finds himself obliged to assign a quite special rank, not to the first only, but, by implication, to the second. To those who see that the essential conceptions on which Psychology in general proceeds, are funished by subjective Psychology—to those who see that such words as feelings, ideas, memories, volitions, have acquired their several meanings through self-analysis, and that the distinctions we make between sensations and emotions, or between automatic acts and voluntary acts, can be established only by comparisons among, and classifications of, our mental states; it will be manifest that objective Psychology can have no existence as such, without borrowing its data from subjective Psychology. And thus perceiving that, until it acknowledges its indebtedness to subjective Psychology, objective Psychology cannot legitimately use any terms that imply consciousness, but must limit itself to nervous co-ordinations considered as physical only; they will see that even objective Psychology contains an element which differentiates it from the rest of the special concrete sciences more than any of these are differentiated from one another.

The claims of Psychology to rank as a distinct science, are thus not smaller but greater than those of any other science. If its phenomena are contemplated objectively, merely as nervo-muscular adjustments by which the higher organisms from moment to moment adapt their actions to environing co-existences and sequences, its degree of speciality, even then, entitles it to a separate place. The moment the element of feeling, or consciousness, is used to interpret nervo-muscular adjustments as thus exhibited in the living beings around, objective Psychology acquires an additional, and quite exceptional, distinction. And it is further distinguished in being linked by this common element of consciousness, to the totally-independent science of subjective Psychology—the two forming together a double science which, as a whole, is quite *sui generis.*

§ 57. So understanding its scope, we are now prepared to enter on the study of Psychology proper. The foregoing discussion serves not unfitly to introduce the several divisions into which the entire subject falls.

First come the Inductions of Psychology; under which title we will deal with the leading empirical generalizations—presenting them, however, under an aspect somewhat different from the usual one. And the truths inductively reached will, when possible, be elucidated deductively, by affiliating them on the truths of Neuro-physiology and Æstho-physiology set down in the foregoing chapters.

We will next pass to Objective Psychology; of which three divisions may conveniently be made. In the first, or General Synthesis, we will trace throughout the animal kingdom, the progress in these perpetual adjustments of special inner actions to special outer actions, which accompanies increasing evolution of the nervous system—omitting, so far as may be, the element of consciousness. In the second, or Special Synthesis, we will consider this same progress more closely, with the view of delineating and formulating it in terms that imply consciousness. And in the third, or Physical Synthesis, an endeavour will be made to show how, by an ultimate principle of nervous action, this progress is explicable as part of Evolution in general.

Turning then to Subjective Psychology, the natures of particular modes of consciousness, as ascertained by introspection, will first be treated under the head of Special Analysis. And then, under the head of General Analysis, we will enter upon the ultimate question of the relation between Thought and Things.

Two remaining divisions will be devoted, the one to a comparison between the results reached in the preceding divisions, with a view of showing their congruity, and the other to a series of corollaries constituting that special part of Human Psychology on which Sociology must be based.

PART II.

THE INDUCTIONS OF PSYCHOLOGY

CHAPTER I.

THE SUBSTANCE OF MIND.

§ 58. To write a chapter for the purpose of showing that nothing is known, or can be known, of the subject which the title of the chapter indicates, will be thought strange. It is, however, in this case needful—needful because, in the absence of explanation, much that has gone before, and much that will come hereafter, may be misinterpreted; and needful also because we have to distinguish between that absolute ignorance and that partial knowledge which may be asserted according as we give one or other meaning to the terms used.

For if by the phrase "substance of Mind," is to be understood Mind as qualitatively differentiated in each portion that is separable by introspection but seems homogeneous and undecomposable; then we do know something about the substance of Mind, and may eventually know more. Assuming an underlying something, it is possible in some cases to see, and in the rest to conceive, how these multitudinous modifications of it arise. But if the phrase is taken to mean the underlying something of which these distinguishable portions are formed, or of which they are modifications; then we know nothing about it, and never can know anything about it. It is not enough to say that such knowledge is beyond the grasp of human intelligence as it now exists; for no amount of that which we call intelligence, however transcendent, can grasp such knowledge.

These two propositions will need a good deal of elucidation. It will be most convenient to deal first with the last of them.

§ 59. To meet all imaginable possibilities, let us set out with the doctrine of Hume, that impressions and ideas are the only things known to exist, and that Mind is merely a name for the sum of them. In this case, the expression "substance of Mind" can have no meaning, unless as applied to each or any impression or idea individually. Whence it follows that there are as many different substances of Mind as there are different impressions and ideas; and this amounts to the conclusion that there is no substance of Mind in the sense implied; or, at any rate, that we have no evidence of its existence. *A fortiori*, the substance of Mind cannot be known.

Contrariwise, let us yield to the necessity of regarding impressions and ideas as forms or modes of a continually-existing something. Failing in every effort to break the series of impressions and ideas in two, we are prevented from thinking of them as separate existences. While each particular impression or idea can be absent, that which holds impressions and ideas together is never absent; and its unceasing presence necessitates, or indeed constitutes, the notion of continuous existence or reality. Existence means nothing more than persistence; and hence in Mind that which persists in spite of all changes, and maintains the unity of the aggregate in defiance of all attempts to divide it, is that of which existence in the full sense of the word must be predicated—that which we must postulate as the substance of Mind in contradistinction to the varying forms it assumes. But if so, the impossibility of knowing the substance of Mind is manifest. By the definition, it is that which undergoes the modification producing a state of Mind. Consequently, if every state of Mind is some modification of this substance of Mind, there can be no state of mind in which the unmodified substance of Mind is present.

Knowing implies something acted upon and something acting upon it. To see that this is undeniable we have but to glance at the three intelligible propositions which can alone be framed respecting the ultimate character of cognition. Suppose the thing presented in consciousness persists unchanged; then, as in the absence of change there is no consciousness, there can be no knowledge. Suppose there follows something which has no determinate relation whatever to its antecedent; then, the change being wholly indeterminate, there is no knowledge, since knowledge is the establishment in thought of determinate relations. Suppose lastly, that the succeeding something has a determinate relation to that which precedes it; then the implication is that the two are linked (if they are not, any other thing may equally well follow); and to think of a special thing (existing) as linked with a special thing (about to exist) is to think of the second as having a speciality resulting from the co-operation of the first and something else. So that be the thing contemplated in the act of cognition a symbolized activity existing beyond the Mind, or be it a past state of Mind itself, that which contemplates it is distinct from it. Hence were it possible for the substance of Mind to be present in any state of Mind, there would still have to be answered the question—What is it which then contemplates it and knows it? That which in the act of knowing is affected by the thing known, must itself be the substance of Mind. The substance of Mind escapes into some new form in recognizing some form under which it has just existed. Hence could the unmodified substance of Mind be presented in consciousness, it would still be unknowable; since, until there had arisen something different from it, the elements of a cognition would not exist; and as this something different would necessarily be some state of Mind, we should have the substance of Mind known in a state of Mind, which is a contradiction. In brief, a thing cannot at the same instant be both subject and object of thought; and yet the substance of Mind must be this before it can be known.

Again, to know anything is to distinguish it as such or such—to class it as of this or that order. An object is said to be but little known, when it is alien to objects of which we have had experience; and it is said to be well known, when there is great community of attributes between it and objects of which we have had experience. Hence, by implication, an object is completely known when this recognized community is complete; and completely unknown when there is no recognized community at all. Manifestly, then, the smallest conceivable degree of knowledge implies at least two things between which some community is recognized. But if so, how can we know the substance of Mind? To know the substance of Mind is to be conscious of some community between it and some other substance. If, with the Idealist, we say that there exists no other substance; then, necessarily, as there is nothing with which the substance of Mind can be even compared, much less assimilated, it remains unknown. While, if we hold with the Realist that Being is fundamentally divisible into that which is present to us as Mind, and that which, lying outside of it, is not Mind; then, as the proposition itself asserts a difference and not a likeness, it is equally clear that Mind remains unclassable and therefore unknowable.

§ 60. From this absolute ignorance of the substance of Mind, considered as the something of which all particular states of Mind are modifications, let us now turn to that partial knowledge of these particular states, as qualitatively characterized, which lies within our possible grasp. Although the individual sensations and emotions, real or ideal, of which consciousness is built up, appear to be severally simple, homogeneous, unanalyzable, or of inscrutable natures, yet they are not so. There is at least one kind of feeling which, as ordinarily experienced, seems elementary, that is demonstrably not elementary. And after resolving it into its proximate components, we can scarcely help suspecting that other apparently-elementary feelings are also compound, and may have proximate components like those which we can in this one instance identify.

Musical sound is the name we give to this seemingly-simple feeling which is clearly resolvable into simpler feelings. Well known experiments prove that when equal blows or taps are made one after another at a rate not exceeding some sixteen per second, the effect of each is perceived as a separate noise; but when the rapidity with which the blows follow one another exceeds this, the noises are no longer identified in separate states of consciousness, and there arises in place of them a continuous state of consciousness, called a tone. On further increasing the rapidity of the blows, the tone undergoes the change of quality distinguished as a rise in pitch; and it continues to rise in pitch as the blows continue to increase in rapidity, until it reaches an acuteness beyond which it is no longer appreciable as a tone. So that out of units of feeling of the same kind, many feelings distinguishable from one another in quality result, according as the units are more or less integrated. This is not all. The inquiries of Professor Helmholtz have shown that when, along with one series of these rapidly-recurring noises, there is generated another series in which the noises are more rapid though not so loud, the effect is a change in that quality of the tone known as its *timbre*. As various musical instruments show us, tones which are alike in pitch and strength are distinguishable by their harshness or sweetness, their ringing or their liquid characters; and all their specific peculiarities are proved to arise from the combination of one, two, three, or more, supplementary series of recurrent noises with the chief series of recurrent noises. So that while the unlikenesses of feeling known as differences of pitch in tones, are due to differences of integration among the recurrent noises of one series, the unlikenesses of feeling known as differences of *timbre*, are due to the simultaneous integration with this series of other series having other degrees of integration. And thus an enormous number of qualitatively-contrasted kinds of consciousness that seem severally elementary, prove to be composed of one simple kind of consciousness, combined and re-combined with itself in multitudinous ways.

Can we stop short here? If the different sensations known as sounds are built out of a common unit, is it not to be rationally inferred that so likewise are the different sensations known as tastes, and the different sensations known as odours, and the different sensations known as colours? Nay, shall we not regard it as probable that there is a unit common to all these strongly-contrasted classes of sensations? If the unlikenesses among the sensations of each class may be due to unlikenesses among the modes of aggregation of a unit of consciousness common to them all; so, too, may the much greater unlikenesses between the sensations of each class and those of other classes. There may be a single primordial element of consciousness, and the countless kinds of consciousness may be produced by the compounding of this element with itself and the re-compounding of its compounds with one another in higher and higher degrees: so producing increased multiplicity, variety, and complexity.

Have we any clue to this primordial element? I think we have. That simple mental impression which proves to be the unit of composition of the sensation of musical tone, is allied to certain other simple mental impressions differently originated. The subjective effect produced by a crack or noise that has no appreciable duration, is little else than a nervous shock. Though we distinguish such a nervous shock as belonging to what we call sounds, yet it does not differ very much from nervous shocks of other kinds. An electric discharge sent through the body, causes a feeling akin to that which a sudden loud report causes. A strong unexpected impression made through the eyes, as by a flash of lightning, similarly gives rise to a start or shock; and though the feeling so named seems, like the electric shock, to have the body at large for its seat, and may therefore be regarded as the correlative rather of the efferent than of the afferent disturbance, yet on remembering the mental change that results from the instantaneous transit of an object across the field of vision, I think it may be perceived that the feeling accompanying the efferent disturbance is itself reduced very nearly to the same form. The state of consciousness so generated is, in fact, comparable in quality to the initial state of consciousness caused by a blow (distinguishing it from the pain or other feeling that commences the instant after); which state of consciousness caused by a blow, may be taken as the primitive and typical form of the nervous shock. The fact that sudden brief disturbances thus set up by different stimuli through different sets of nerves, cause feelings scarcely distinguishable in quality, will not appear strange when we recollect that distinguishableness of feeling implies appreciable duration; and that when the duration is greatly abridged, nothing more is known than that some mental change has occurred and ceased. To have a sensation of redness, to know a tone as acute or grave, to be conscious of a taste as sweet, implies in each case a considerable continuity of state. If the state does not last long enough to admit of its being contemplated, it cannot be classed as of this or that kind; and becomes a momentary modification very similar to momentary modifications otherwise caused.

It is possible, then—may we not even say probable—that something of the same order as that which we call a nervous shock is the ultimate unit of consciousness; and that all the unlikenesses among our feelings result from unlike modes of integration of this ultimate unit. I say of the same order, because there are discernible differences among nervous shocks that are differently caused; and the primitive nervous shock probably differs somewhat from each of them. And I say of the same order for the further reason, that while we may ascribe to them a general likeness in nature we must suppose a great unlikeness in degree. The nervous shocks recognized as such, are violent--must be violent before they can be perceived amid the procession of multitudinous vivid feelings suddenly interrupted by them. But the rapidly-recurring nervous shocks of which the different forms of feeling consist, we must assume to be of comparatively moderate, or even of very slight, intensity. Were our various sensations and emotions composed of rapidly-recurring shocks as strong as those ordinarily called shocks, they would be unbearable: indeed life would cease at once. We must think of them rather as successive faint pulses of subjective change, each having the same quality as the strong pulse of subjective change distinguished as a nervous shock.

The reader will at once see, if he has not already seen, the complete congruity between this view and the known character of nerve-action. As pointed out in § 33, experiments show that the so-called nerve-current is intermittent —consists of waves which follow one another from the place where the disturbance arises to the place where its effect is felt. The external stimulus in no case acts continuously on the sentient centre, but sends to it a series of pulses of molecular motion. Hence, in concluding that the subjective effect or feeling, is composed of rapidly-recurring mental shocks, we simply conclude that it corresponds with the objective cause—the rapidly-recurring shocks of molecular change. Our typical case of musical sound well exhibits the agreement. We have a single aërial wave, a single movement of the drum of the ear, a single impact on the expansion of the auditory nerve, a single wave propagated to the auditory centre, and a single shock of feeling known as a crack or a report; and then, when there is externally generated a succession of such aërial waves, each working its individual physical effect on the auditory structures, and its individual psychical effect as a kind of shock, we see that if the recurrent physical effects exceed a certain speed, the recurrent psychical effects are consolidated into a sensation of tone. So that here the nerve pulses and the pulses of feeling clearly answer to one another; and it can scarcely be doubted that they do so throughout.*

We must not omit a further indirect evidence equally unlooked for and striking. A conceivable solution is afforded by this hypothesis of two problems which, in its absence, seem entirely insoluble. How is it possible for

* Though in the cases of the other sensations, it is equally certain that the disturbances propagated through the afferent and centripetal nerves are intermittent, yet we cannot in the same way trace the genesis of the successive waves. A tolerably good clue to their mode of genesis, is, however, furnished by the action of light on the retina. Possibly it will be anticipated that I am about to assign the rapidly-recurring pulses of the etherial medium, as the causes of pulses recurring with equal rapidity in the optic nerves; but I am far from intending to do this. Neither the velocities of the nerve-waves, nor the intervals between the nerve-waves, would yield the least countenance to such an interpretation ; even were it reconcilable with the principles of physics. Undulating molecules of ether acting on the immeasurably-heavier undulating molecules of matter, can work appreciable changes in them only by accumulation of minute effects. If certain etherial undulations correspond in rate with the undulations of some molecule of matter united with others into a compound; then this molecule may, by a long succession of etherial impacts, have its oscillations so increased in their sweep as to cause detachment of it, and consequent decomposition of the compound molecule (*Principles of Biology*, § 13). But for the effects of etherial impacts to be thus accumulated, time is required; and appreciable time is experimentally shown to be taken by the decompositions which light effects. Hence, then, a ray of light falling on one of the sensitive elements of the retina, may be supposed to decompose now one unstable molecule and now another, at intervals very long as compared with those of the etherial undulations, though very short as estimated by our measures; and the decomposition of each molecule may be supposed to send along a connected nerve-fibre, the wave of molecular change which, under its subjective aspect as a nervous shock, becomes the unit of composition of the sensation called light.

feelings so different in quality as those of heat, of taste, of colour, of tone, &c., to arise in nervous centres closely allied to one another in composition and structure? And how, in the course of evolution, can there have been gradually differentiated these widely-unlike orders, and genera, and species, of feelings? Possible answers are at once supplied if we assume that diverse feelings are produced by diverse modes, and degrees, and complexities, of integration of the alleged ultimate unit of consciousness. If each wave of molecular motion brought by a nerve-fibre to a nerve-centre, has for its correlative a shock or pulse of feeling; then we can comprehend how distinguishable differences of feeling may arise from differences in the rates of recurrence of the waves, and we can frame a general idea of the way in which, by the arrival through other fibres, of waves recurring at other rates, compound waves of molecular motion may be formed, and give rise to units of compound feelings: which process of compounding of waves and production of correspondingly-compounded feelings, we may imagine to be carried on without limit, and to produce any amount of heterogeneity of feelings. After recognizing this possibility, the visible likenesses of nervous centres that are the seats of different feelings, cease to be mysterious; since the structures of these nervous centres need differ only as much as is requisite to produce different combinations of the waves of molecular motion. Similarly, there disappears the difficulty of understanding how the multitudinous diverse forms of feeling have been evolved from a primitive simple sensibility; since complications of the molecular motions, and concomitant feelings, must have gone on *pari passu* with correlative complications of minute structures, organized little by little.

§ 61. The nature of Mind as thus conceived, will be elucidated by comparing it with the nature of Matter; and the fact that a parallelism exists between that which chemists have established respecting Matter and that which we here suppose respecting Mind, will help to justify the conception.

Multitudinous substances that seem to be homogeneous and simple, prove to be really heterogeneous and compound; and many that appear wholly unrelated are shown by analysis to be near akin. Here is a group of them quite different in their apparent characters, which have an essential component in common. Here is another group similarly held together by the universal presence of some other component. And then these seemingly-different substances each characterizing a different group, turn out themselves to contain an element common to the two. For instance, there is a large class of salts formed by sulphuric acid; another large class formed by nitric acid; another by acetic acid; and so on. And these acids, along with many others, are all discovered to have oxygen for their active constituent. Moreover, there is reason to suspect that the so-called simple substances are themselves compound; and that there is but one ultimate form of Matter, out of which the successively-more complex forms of Matter are built up. By the different grouping of units, and by the combination of the unlike groups each with its own kind and each with other kinds, it is supposed that there have been produced the kinds of matter we call elementary; just as, by further compositions similarly carried on, these produce further varieties and complexities. And this supposition the phenomena of allotropism go far to justify, by showing us that the same mass of molecules assumes quite different properties when the mode of aggregation is changed.

If, then, we see that by unlike arrangements of like units, all the forms of Matter, apparently so diverse in nature, may be produced—if, even without assuming that the so-called elements are compound, we remember how from a few of these there may arise by transformation and by combination numerous seemingly-simple substances, strongly contrasted with their constituents and with one another; we shall the better conceive the possibility that the multitudinous forms of Mind known as different feelings, may be composed of simpler units of feeling, and even of units fundamentally of one kind. We shall perceive that such homogeneous units of feeling may, by integration in diverse ways, give origin to different though relatively-simple feelings; by combination of which with one another more complex and more unlike feelings may arise; and so on continuously.

Here, indeed, it may be added that something beyond analogy may perhaps exist between the methods of material and mental evolution. When we recall the fact that molecules are never at rest, and that by carrying their individual rhythmical motions into the compound molecules formed of them, they produce compound rhythms—when we recollect the extreme complexity of the molecules of nervous matter, and imagine how various and involved must be the rhythms of which they are the seats—when, further, we infer the countless modifications of rhythms that must under such conditions become possible; we shall dimly see a fitness of molecular structure for originating, and being affected by, the diversities and complications of molecular pulses above described. We shall suspect that there may be here a further correspondence between a known cause of physical heterogeneity and the supposed cause of psychical heterogeneity.

§ 62. While reading the last two sections, some will perhaps have thought that they stand in direct contradiction to the section preceding them. After alleging that the substance of Mind cannot be known, an attempt is forthwith made to show that Mind is, certainly in some cases and probably in all, resolvable into nervous shocks; and that these nervous shocks answer to the waves of molecular motion that traverse nerves and nerve-centres.

Thus not only is the substance of Mind supposed to be knowable as having this universal character, but it is closely assimilated to, if not identified with, nervous change.

The alarm is groundless however. The foregoing reasoning brings us no nearer to a solution of the final question. Even could we succeed in proving that Mind consists of homogeneous units of feeling of the nature specified, we should be unable to say what Mind is; just as we should be unable to say what Matter is, could we succeed in decomposing it into those ultimate homogeneous units of which it is not improbably composed. In the one case, as in the other, the ultimate unit must remain, for the reasons assigned at the outset, absolutely unknown. The reduction of all the more complex forms to the simplest form, leaves us with nothing but this simplest form as the term out of which to frame thought; and thought cannot be framed out of one term only. Representation and re-representation of this ultimate unit of consciousness in terms of itself, leaves us at last just where we were at first. And representation of it in any other terms involves a contradiction. For to think of it as having some assigned nature, is to think of it in some other mode of consciousness; in which case such other mode of consciousness cannot have this unit of consciousness for its component, which is contrary to the hypothesis.

When the two modes of Being which we distinguish as Subject and Object, have been severally reduced to their lowest terms, any further comprehension must be an assimilation of these lowest terms to one another; and, as we have already seen, this is negatived by the very distinction of Subject and Object, which is itself the consciousness of a difference transcending all other differences. So far from helping us to think of them as of one kind, analysis serves but to render more manifest the impossibility of finding for them a common concept—a thought under which they can be united.

Let it be granted that all existence distinguished as objective, may be resolved into the existence of units of one kind. Let it be granted that every species of objective activity, may be understood as due to the rhythmical motions of such ultimate units; and that among the objective activities so understood, are the waves of molecular motion propagated through nerves and nerve-centres. And let it further be granted that all existence distinguished as subjective, is resolvable into units of consciousness similar in nature to those which we know as nervous shocks; each of which is the correlative of a rhythmical motion of a material unit, or group of such units. Can we then think of the subjective and objective activities as the same? Can the oscillation of a molecule be represented in consciousness side by side with a nervous shock, and the two be recognized as one? No effort enables us to assimilate them. That a unit of feeling has nothing in common with a unit of motion, becomes more than ever manifest when we bring the two into juxtaposition. And the immediate verdict of consciousness thus given, might be analytically justified were this a fit place for the needful analysis. For it might be shown that the conception of an oscillating molecule is built out of many units of feeling; and that to identify it with a nervous shock would be to identify a whole congeries of units with a single unit.

§ 63. Here, indeed, we arrive at the barrier which needs to be perpetually pointed out; alike to those who seek materialistic explanations of mental phenomena, and to those who are alarmed lest such explanations may be found. The last class prove by their fear, almost as much as the first prove by their hope, that they believe Mind may possibly be interpreted in terms of Matter; whereas many whom they vituperate as materialists, are profoundly convinced that there is not the remotest possibility of so interpreting them. For those who, not deterred by foregone conclusions, have pushed their analyses to the uttermost, see very clearly that the concept we form to ourselves of Matter, is but the symbol of some form of Power absolutely and for ever unknown to us; and a symbol which we cannot suppose to be like the reality without involving ourselves in contradictions (*First Principles*, § 16). They also see that the representation of all objective activities in terms of Motion, is but a representation of them and not a knowledge of them; and that we are immediately brought to alternative absurdities if we assume the Power manifested to us as Motion, to be in itself that which we conceive as Motion (*First Principles*, § 17). When with these conclusions that Matter and Motion as we think them are but symbolic of unknowable forms of existence, we join the conclusion lately reached that Mind also is unknowable, and that the simplest form under which we can think of its substance is but a symbol of something that can never be rendered into thought; we see that the whole question is at last nothing more than the question whether these symbols should be expressed in terms of those or those in terms of these—a question scarcely worth deciding; since either answer leaves us as completely outside of the reality as we were at first.

Nevertheless, it may be as well to say here, once for all, that were we compelled to choose between the alternatives of translating mental phenomena into physical phenomena, or of translating physical phenomena into mental phenomena, the latter alternative would seem the more acceptable of the two. Mind, as known to the possessor of it, is a circumscribed aggregate of activities; and the cohesion of these activities, one with another, throughout the aggregate, compels the postulation of a something of which they are the activities. But the same experiences which make him aware of this coherent aggregate of mental activities, simultaneously make him aware of activities that are not included in it—outlying activities which become known by their effects on this aggregate, but which are experimentally proved to be not coherent with it, and to be coherent with one another (*First Principles*, §§ 43, 44). As, by the definition of them, these external activities cannot be brought within the aggregate of activities distinguished as those of Mind, they must for ever remain to him nothing more than the unknown correlatives of their effects on this aggregate; and can be thought of only in terms furnished by this aggregate. Hence, if he regards his conceptions of these activities lying beyond Mind, as constituting knowledge of them, he is deluding himself: he is but representing these activities in terms of Mind, and can never do otherwise. Eventually he is obliged to admit that his ideas of Matter and Motion, merely symbolic of unknowable realities, are complex states of consciousness built out of units of feeling. But if, after admitting this, he persists in asking whether units of feeling are of the same nature as the units of force distinguished as external, or whether the units of force distinguished as external are of the same nature as units of feeling; then the reply, still substantially the same, is that we may go farther towards conceiving units of external force to be identical with units of feeling, than we can towards conceiving units of feeling to be identical with units of external force. Clearly, if units of external force are regarded as absolutely unknown and unknowable, then to translate units of feeling into them is to translate the known into the unknown, which is absurd. And if they are what they are supposed to be by those who identify them with their symbols, then the difficulty of translating units of feeling into them is insurmountable: if Force as it objectively exists is absolutely alien in nature from that which exists subjectively as Feeling, then the transformation of Force into Feeling is unthinkable. Either way, therefore, it is impossible to interpret inner existence in terms of outer existence. But if, on the other hand, units of Force as they exist objectively, are essentially the same in nature with those manifested subjectively as units of Feeling; then a conceivable hypothesis remains open. Every element of that aggregate of activities constituting a consciousness, is known as belonging to consciousness only by its cohesion with the rest. Beyond the limits of this coherent aggregate of activities, exist activities quite independent of it, and which cannot be brought into it. We may imagine, then, that by their exclusion from the circumscribed activities constituting consciousness, these outer activities, though of the same intrinsic nature, become antithetically opposed in aspect. Being disconnected from consciousness, or cut off by its limits, they are thereby rendered foreign to it. Not being incorporated with its activities, or linked with these as they are with one another, consciousness cannot, as it were, run through them; and so they come to be figured as unconscious—are symbolized as having the nature called material as opposed to that called spiritual. While, however, it thus seems an imaginable possibility that units of external Force may be identical in nature with units of the force known as Feeling, yet we cannot by so representing them get any nearer to a comprehension of external Force. For, as already shown, supposing all forms of Mind to be composed of homogeneous units of feeling variously aggregated, the resolution of them into such units leaves us as unable as before to think of the substance of Mind as it exists in such units; and thus, even could we really figure to ourselves all units of external Force as being essentially like units of the force known as Feeling, and as so constituting a universal sentiency, we should be as far as ever from forming a conception of that which is universally sentient.

Hence though of the two it seems easier to translate so-called Matter into so-called Spirit, than to translate so-called Spirit into so-called Matter (which latter is, indeed, wholly impossible); yet no translation can carry us beyond our symbols. Such vague conceptions as loom before us are illusions conjured up by the wrong connotations of our words. The expression "substance of Mind," if we use it in any other way than as the x of our equation, inevitably betrays us into errors; for we cannot think of substance save in terms that imply material properties. Our only course is constantly to recognize our symbols as symbols only; and to rest content with that duality of them which our constitution necessitates. The Unknowable as manifested to us within the limits of consciousness in the shape of Feeling, being no less inscrutable than The Unknowable as manifested beyond the limits of consciousness in other shapes, we approach no nearer to understanding the last by rendering it into the first. The conditioned form under which Being is presented in the Subject, cannot, any more than the conditioned form under which Being is presented in the Object, be the Unconditioned Being common to the two.

CHAPTER II.

THE COMPOSITION OF MIND.

§ 64. In the last chapter we incidentally encroached on the topic to which this chapter is to be devoted. Certain apparently-simple feelings were shown to be compounded of units of feeling; whence it was inferred that possibly, if not probably, feelings of other classes are similarly compounded. And in thus treating of the composition of feelings, we, by implication, treated of the composition of Mind, of which feelings are themselves components.

Here, however, leaving speculations about the ultimate composition of Mind, we pass to observations on its proximate composition. Accepting as really simple those constituents of Mind which are not decomposable by introspection, we have to consider what are their fundamental distinctive characters, and what are the essential principles of arrangement among them.

§ 65. The proximate components of Mind are of two broadly-contrasted kinds—Feelings and the Relations between feelings. Among the members of each group there exist multitudinous unlikenesses, many of which are extremely strong; but such unlikenesses are small compared with those which distinguish members of the one group from members of the other. Let us, in the first place, consider what are the characters which all Feelings have in common, and what are the characters which all Relations between feelings have in common.

Each feeling, as we here define it, is any portion of consciousness which occupies a place sufficiently large to give it a perceivable individuality; which has its individuality marked off from adjacent portions of consciousness by qualitative contrasts; and which, when introspectively contemplated, appears to be homogeneous. These are the essentials. Obviously if, under introspection, a state of consciousness is decomposable into unlike parts that exist either simultaneously or successively, it is not one feeling but two or more. Obviously if it is indistinguishable from an adjacent portion of consciousness, it forms one with that portion—is not an individual feeling but part of one. And obviously if it does not occupy in consciousness an appreciable area, or an appreciable duration, it cannot be known as a feeling.

A relation between feelings is, on the contrary, characterized by occupying no appreciable part of consciousness. Take away the terms it unites, and it disappears along with them; having no independent place—no individuality of its own. It is true that, under an ultimate analysis, what we call a relation proves to be itself a kind of feeling—the momentary feeling accompanying the transition from one conspicuous feeling to an adjacent conspicuous feeling. And it is true that, notwithstanding its extreme brevity, its qualitative character is appreciable; for relations are (as we shall hereafter see) distinguishable from one another only by the unlikenesses of the feelings which accompany the momentary transitions. Each relational feeling may, in fact, be regarded as one of those nervous shocks which we suspect to be the units of composition of feelings; and, though instantaneous, it is known as of greater or less strength and as taking place with greater or less facility. But the contrast between these relational feelings and what we ordinarily call feelings, is so strong that we must class them apart. Their extreme brevity, their small variety, and their dependence on the terms they unite, differentiate them in an unmistakeable way.*

Perhaps it will be well to recognize more fully the truth that this distinction cannot be absolute. Besides admitting that, as an element of consciousness, a relation is a momentary feeling, we must also admit that just as a relation can have no existence apart from the feelings which form its terms, so a feeling can exist only by relations to other feelings which limit it in space or time or both. Strictly speaking, neither a feeling nor a relation is an independent element of consciousness: there is throughout a dependence such that the appreciable areas of consciousness occupied by feelings, can no more possess individualities apart from the relations which link them, than these relations can possess individualities apart from the feelings they link. The essential distinction between the two, then, appears to be that whereas a relational feeling is a portion of consciousness inseparable into parts, a feeling ordinarily so-called, is a portion of consciousness that admits imaginary division into like parts which are related to one another in sequence or co-existence. A feeling proper is either made up of like parts that occupy time, or it is made up of like parts that occupy space, or both. In any case, a feeling proper is an aggregate of related like parts, while a relational feeling is undecomposable. And this is exactly the contrast between the two which must result if, as we have inferred, feelings are composed of units of feeling, or shocks.

§ 66. Simple feelings as above defined, are of various kinds. To say anything here about the classification of

* It will perhaps be objected that some relations, as those between things which are distant in Space or in Time, occupy distinguishable portions of consciousness. These, however, are not the simple relations between adjacent feelings which we are here dealing with. They are relations that bridge over great numbers of intervening feelings and relations; and come into existence only by quick transitions through these intervening states, ending in the consolidation of them.

them, involves some forestalling of a future chapter. This breach of order, however, is unavoidable; for until certain provisional groupings have been made, further exposition is scarcely practicable.

Limiting our attention to seemingly-homogeneous feelings as primarily experienced, they may be divided into the feelings which are centrally initiated and the feelings which are peripherally initiated—emotions and sensations. These have widely unlike characters. Towards the close of this volume evidence will be found that while the sensations are relatively simple, the emotions, though seeming to be simple are extremely compound; and that a marked contrast of character between them hence results. But without referring to any essential unlikeness of composition, we shall shortly see that between the centrally-initiated feelings and the peripherally-initiated feelings, fundamental distinctions may be established by introspective comparison.

A subdivision has to be made. The peripherally-initiated feelings, or sensations, may be grouped into those which, caused by disturbances at the ends of nerves distributed on the outer surface, are taken to imply outer agencies, and those which, caused by disturbances at the ends of nerves distributed within the body, are not taken to imply outer agencies; which last, though not peripherally initiated in the ordinary sense, are so in the physiological sense. But as between the exterior of the body and its interior, there are all gradations of depth, it results that this distinction is a broadly marked one, rather than a sharply marked one. We shall, however, find that certain differential characters among the sensations accompany this difference of distribution of the nerves in which they arise; and that they are decided in proportion to the relative superficiality or centrality of these nerves.

In contrast with this class of primary or real feelings, thus divided and subdivided, has to be set the complementary class of secondary or ideal feelings, similarly divided and subdivided. Speaking generally, the two classes differ greatly in intensity. While the primary or originally-produced feelings are relatively vivid, the secondary or re-produced feelings are relatively faint. It should be added that the vivid feelings are taken to imply objective exciting agents then and there acting on the periphery of the nervous system; while the faint feelings, though taken to imply objective exciting agents which thus acted at a past time, are not taken to imply their present action.

We are thus obliged to carry with us a classification based on structure and a classification based on function. The division into centrally-initiated feelings, called emotions, and peripherally-initiated feelings, called sensations; and the subdivision of these last into sensations that arise on the exterior of the body and sensations that arise in its interior; respectively refer to differences among the parts in action. Whereas the division into vivid or real feelings and faint or ideal feelings, cutting across the other divisions at right angles as we may say, refers to difference of amount in the actions of these parts. The first classification has in view unlikenesses of kind among the feelings; and the second, a marked unlikeness of degree, common to all the kinds.

§ 67. From the classes of simple feelings we pass to the classes of simple relations between feelings, respecting which also, something must be said before we can proceed. In default of an ultimate analysis, which cannot be made at present, certain brief general statements must suffice.

As already said, the requisite to the existence of a relation is the existence of two feelings between which it is the link. The requisite to the existence of two feelings is some difference. And therefore the requisite to the existence of a relation is the occurrence of a change—the passage from one apparently-uniform state to another apparently-uniform state, implying the momentary shock produced by the commencement of a new state.

It follows that the degree of the change or shock, constituting in other words the consciousness of the degree of difference between the adjacent states, is the ultimate basis of the distinctions among relations. Hence the fundamental division of them into relations between feelings that are equal, or those of likeness, (which however must be divided by some portion of consciousness that is unlike them), and relations between feelings that are unequal, or those of unlikeness. These last fall into what we may distinguish as relations of descending intensity and relations of ascending intensity, according as the transition is to a greater or to a less amount of feeling. And they are further distinguishable into relations of quantitative unlikeness, or those occurring between feelings of the same nature but different in degree, and relations of qualitative unlikeness, or those occurring between feelings not of the same nature.

Relations thus contemplated simply as changes, and grouped according to the degree of change or the kind of change, severally belong to one or other of two great categories which take no account of the terms as like or unlike in nature or amount, but which take account only of their order of occurrence, as either simultaneous or successive. This fundamental division of relations into those of co-existence and those of sequence, is, however, itself dependent on the preceding division into relations of equality between feelings and relations of inequality between them. For relations themselves have to be classed as of like or unlike kinds by comparing the momentary feelings that attend the establishment of them, and observing whether these are like or unlike; and, as we shall hereafter see, the relations of co-existence and sequence are distinguished from one another only by a process of this kind.

§ 68. Having defined simple feelings and simple relations, and having provisionally classified the leading kinds of each, we may now go on to observe how Mind is made up of these elements, and how different portions of it are characterized by different modes of combination of them.

Tracts of consciousness formed of feelings that are centrally initiated, are widely unlike tracts of consciousness formed of feelings that are peripherally initiated; and of the tracts of consciousness formed of peripherally-initiated feelings, those parts occupied by feelings that take their rise in the interior of the body are widely unlike those parts occupied by feelings that take their rise on the exterior of the body. The marked unlikenesses are in both cases due to the greater or smaller proportions of the relational elements that are present. Whereas among centrally-initiated feelings, the mutual limitations, both simultaneous and successive, are vague and far between; and whereas among peripherally-initiated feelings caused by internal disturbances, some are extremely indefinite, and few or none definite in a high degree; feelings caused by external disturbances are mostly related quite clearly, alike by coexistence and sequence, and among the highest of them the mutual limitations in space or time or both, are extremely sharp. These broad contrasts, dependent on the extent to which the elements of feeling are compounded with the elements of relation, cannot be understood, and their importance perceived, without illustrations. We will begin with those parts of Mind distinguished by predominance of the relational elements.

Remembering that the lenses of the eye form a nonsentient optical apparatus that casts images on the retina, we may fairly say that the retina is brought more directly into contact with the external agent acting on it than is any other peripheral expansion of the nervous system. And it is in the tracts of consciousness produced by the various lights reflected from objects around and concentrated on the retina, that we find the elements of feeling most intimately woven up with the elements of relation. The multitudinous states of consciousness yielded by vision, are above all others sharp in their mutual limitations: the differences that occur between adjacent ones are extremely definite. It is further to be noted that the relational element is here dominant under both of its fundamental forms. Some of the feelings simultaneously limit one another with great distinctness, and some of them with equal distinctness successively limit one another. The feelings caused by actions on the general surface of the body are also marked off clearly, though by no means so clearly as those which arise in the retina. Sensations of touch initiated at points on the skin very near one another, form parts of consciousness that are separate though adjacent; and these are distinguishable not only as co-existing in close proximity, but also as distinct from kindred sensations immediately preceding or immediately succeeding them. Moreover the definiteness of their mutual limitations, in space if not in time, is greatest among the sensations of touch proceeding from parts of the surface which have, in a sense, the greatest externality—the parts which, like the tips of the fingers and the tip of the tongue, have the most frequent and varied converse with outer objects.* Next in the definiteness of their mutual limitations come the auditory feelings. Among such of these as occur together, the relations are marked with imperfect clearness. Received through uncultivated ears, only a few simultaneous sounds are vaguely separable in consciousness; though received through the ears of a musician, many such sounds may be distinguished and identified. But among successive sounds the relational components of mind are conspicuous. Differences between tones that follow one another, even very rapidly, are clearly

* The tongue is a much more active tactual organ than at first appears. The mechanical impressions it receives are not limited to those given by the food which it manages during mastication: but at other times it is perpetually exploring the inner surfaces of the teeth, which are to it external bodies.

perceived. But the demarcations are less decided than those between contrasted sensations in the field of vision. Passing to the sensations of taste, we see that these, less external in their origin (for it is not in the tip of the tongue, but over its hinder part and the back of the palate, that the gustatory nerves are distributed), are comparatively indefinite in their relations. Such distinctions as may be perceived between tastes that co-exist are comparatively vague, and can be extended to but two or three. Similarly, the beginnings and ends of successive tastes are far less sharp than the beginnings and ends of the visual impressions we receive at every glance; nor can successive tastes be distinguished with anything like the same rapidity as successive tones. Even more undecided are the mutual limitations among sensations of smell, which, like the last, originate at a considerable distance from the surface (for the nose is not the seat of smell: the olfactory chamber, with which the nostrils communicate, is seated high up between the eyes). Of simultaneous smells the discrimination is very vague; and probably not more than three can be separately identified. Of smells that follow one another, it is manifest that they begin and end indefinitely, and that they cannot be experienced in rapid succession.

We come now to the peripherally-initiated feelings set up by internal disturbances. Among these the most superficial in origin and most relational as they exist in consciousness, are the sensations of muscular tension. Though, except when making vigorous efforts, these are but feeble; though such as are present together mutually limit one another in a very vague way; and though their beginnings and ends are so blurred that a series of them is but indistinctly separable into parts; yet they are juxtaposed and contrasted to the extent implied by discriminations and recognitions of them—discriminations and recognitions so partial, however, as frequently to require indirect verifications. It should be added that the relations among muscular feelings are variable in abundance and distinctness. They are most conspicuous when the feelings come from muscles that are small, and in perpetual action, as those which move the eyes, the fingers, and the vocal organs; and least conspicuous when the feelings come from muscles that are large or centrally seated, or both, as those of the legs and of the trunk. Passing over abnormal feelings of pain and discomfort due to disturbances of nerves distributed within the limbs and body, among which the small proportion of the relational element is manifest, it will suffice if we come at once to the feelings originating in parts that are remotest from the external world, and which, as least relational, are most distinguished from those we set out with. Hunger is extremely vague in its beginning and end. Commencing unobtrusively and ceasing gradually, it is utterly unlike those feelings which, closely contiguous in time, make one another distinct by mutual limitation. Neither is it appreciably marked out by co-existing feelings: its position among simultaneous states of consciousness is indeterminate. And this indefiniteness of relation, both in space and time, characterizes other visceral feelings, both normal and abnormal.

Of the centrally-initiated feelings, or emotions, much the same has to be said as of the last. Their beginnings and endings in time are comparatively indefinite, and they have no definite localizations in space. That is to say, they are not limited by preceding and succeeding states of consciousness with any precision; and no identifiable bounds are put to them by states of consciousness that co-exist. Here, then, the relational element of mind is extremely inconspicuous. The sequences among emotions that can occur in a given period, are comparatively few and indeterminate; and between such two or three emotions as can co-exist it is impossible to distinguish in more than a vague way.

§ 69. Further and equally-important distinctions obtain between the tracts of consciousness thus broadly contrasted, and they are similarly caused. Presence of the relational elements, seen in the mutual limitations of feelings, simultaneous and successive, is accompanied by the mutual cohesion of feelings; and absence of the relational elements, seen in the indeterminate boundaries of feelings in space and time, is accompanied by their incoherence. Let us re-observe the tracts of consciousness above compared.

The sharply-defined patches of colour that occur together in a visual impression, are indissolubly united—held rigidly in juxtaposition. And successive visual feelings, such as are produced by transferring the gaze from one object to another, have a strength of connection that gives a fixed consciousness of their order. Thus the visual feelings, above all others distinguished by the sharpness of their mutual limitations, are absolutely coherent in space and very coherent in time. Between sensations of touch given by an object grasped, the cohesion is not so great. Though the two feelings produced by two points felt simultaneously by a finger, hold together so that they cannot be removed far from one another in consciousness; yet the bond uniting them has much less rigidity than the bond uniting the visual feelings produced by the two points; and when the feelings are more than two, their connections in consciousness are loose enough to permit of much variation in the conception of their relative positions. Still the strength of links between co-existing feelings of touch is considerable; as is also that between successive feelings of the same kind. Among the simultaneous feelings caused by simultaneous sounds, especially if they are not in harmony, the defect of cohesion is as marked as the defect of mutual limitation. But among the successive feelings produced by successive sounds, we find that along with distinct mutual limitations there go decided mutual cohesions. Sequent notes, or articulations, cling together with tenacity. Much less clearly bounded by one another as are tastes, simultaneous and successive, they are also comparatively incoherent. Among co-existent tastes there are no connections like those between co-existent visual feelings, or even like those between the sounds produced at the same instant by a band; and tastes do not hold together in sequence as do the tones of cadence. Of smells the like is true. Along with vagueness in the bounding of one by another there goes but a feeble linking together.

The feelings accompanying muscular actions have cohesions that are hidden in much the same way as are their limitations. The difficulty of observing the mutual limitations of muscular feelings, is due to the fact that each muscle, or set of muscles, passes from a state of rest to a state of action or from a state of action to a state of rest, through gradations that occupy an appreciable time; and that, consequently, the accompanying feeling, instead of beginning and ending strongly, shades off at both extremes. Being thus weak at the places where they are contiguous, these feelings are incapable of strong cohesions. Indeed, if we except those which accompany great efforts, we may say that they are altogether so faint compared with most others that their relations, both in kind and order, are necessarily inconspicuous. Their cohesions are in a great degree those of automatic nervous acts; and are by so much the less the cohesions of conscious states. Those very vague feelings which have their seats in the viscera, may, as before, be exemplified by hunger. Here where we reach such extreme indefiniteness of limitation, both in space and time, we reach an extreme want of cohesion. Hunger does not suddenly follow some other into consciousness; nor is it suddenly followed by some other. Neither is there any simultaneous feeling to which it clings. The relational element of Mind is almost absent; holding only in a feeble degree with some tastes and smells.

Lastly, among the centrally-initiated feelings, or emotions, the same connection of characters occurs. When emotions co-exist, they can scarcely be said to hold together: the bond between them is so feeble, that each may disappear without affecting the others. Between sequent emotions the links have no appreciable strength: no one is attached to another in such way as to produce constancy of succession. And though between emotions and certain more definite feelings which precede them, there are strong connections, yet these connections are not between emotions and single antecedent feelings, but between emotions and large groups of antecedent feelings; and even this cohesion, very variable in its strength, may entirely fail.

§ 70. A further trait in the composition of Mind, dependent on these correlated traits, may next be set down. We have seen that tracts of consciousness formed of feelings produced by external disturbances, are mostly distinguished by predominance of the relational element, involving clearness of mutual limitation and strength of cohesion among the component feelings; and we have seen that, contrariwise, the feelings produced by internal disturbances, peripheral and central, are mostly distinguished by comparative want of the relational element, involving proportionate defect of mutual limitation and cohesion. We have now to observe that the tracts of consciousness thus broadly contrasted, are, by consequence, broadly contrasted in the respect that, in the one case, the component feelings can unite into coherent and well-defined clusters, while, in the other case, they cannot so unite.

The state of consciousness produced by an object seen, is composed of sharply-outlined lights, shades, and colours, and the co-existent feelings and relations entering into one of these groups form an indissoluble whole. To a considerable degree, successive visual feelings cling together in defined groups. As most of them are caused by moving objects more or less complex, it is difficult to trace this clustering of them in sequence apart from their clustering in co-existence. But if we take the case of a bird that suddenly flies past close to a window out of which we are looking, it is manifest that the successive feelings form a consciousness of its line of movement so defined and coherent that we know, without having moved the eyes, what was its exact course. The clustering of auditory feelings, comparatively feeble among those occurring simultaneously, is comparatively strong among those occurring successively. Hence the consolidated groups of sounds which we know in consciousness as words. Hence the chains of notes which we remember as musical phrases. The clustering of tactual feelings in relations of co-existence, though by no means so decided as the clustering of co-existent visual feelings, either in the extent or complexity of the clusters or the firmness with which their components are united, is nevertheless considerable. When the hand is laid on some small object, as a key, a number of impressions may be distinguished as separate though near one another; but while their mutual relations are so far fixed that approximate limits within which they exist are known, they do not constitute anything like such a fixed and defined group as those given by vision of the key. This imperfect clustering in co-existence is accompanied by imperfect clustering in sequence. The successive feelings produced by a fly creeping over the hand, hold together strongly enough and definitely enough to constitute a consciousness of its general movement as being towards the wrist or from the wrist, across from right to left or from left to right; but they do not form a consciousness of its exact course. Tastes unite only into very simple and incoherent clusters in co-existence; while in sequence they scarcely unite at all. And the like is true of smells.

Such capability of clustering as is displayed by the peripherally-initiated feelings caused by internal disturbances, occurs among those accompanying the movements of muscles. But, along with the comparative vagueness of limitation and want of strong cohesion which characterize these feelings, there goes a comparative indistinctness of the clusters. Though the nervous acts of which muscular motions are results, combine into groups with much precision, yet the combination of them, at first feeble, becomes strong only by repetition. And as the repetition which makes the combination strong, makes it to the same extent automatic, the concomitant feelings become less and less distinct, and fade from consciousness as fast as they unite. How, in muscular acts, complete clustering and unconsciousness go together, is seen in the fact that consciousness impedes clustered muscular acts. After having many times gone through the series of compound movements required, it is possible to walk across the room in the dark and lay hold of the handle of the door—so long, that is, as the movements are gone through unthinkingly. If they are consciously made, failure is almost certain. Of the further class of feelings initiated within the body, including appetites, pains, &c., it is scarcely needful to say that there is among them no formation of coherent groups. Their great indefiniteness of limitation and accompanying want of cohesion, forbid unions of them, either simultaneous or successive.

Obviously the emotions are characterized by a like want of combining power. A confused and changing chaos is produced by any of them which co-exist. In fact, the absence among them of capacity for uniting, is as marked as its presence among those visual feeling with which we set out.

§ 71. We come now to more complex manifestations of these general contrasts. In tracts of consciousness where the relational element predominates, and where the clustering of feelings is consequently decided, the clusters themselves enter into relations one with another. Grouped feelings, together with the relations uniting them, are fused into wholes which, comporting themselves as single feelings do, combine with other such consolidated groups in definite relations; and even groups of groups, similarly fused, become in like manner limited by, and coherent with, other groups of groups. Conversely, in tracts of consciousness where the relations are few and vague, nothing of the kind takes place.

It is among the visual feelings, above all others multitudinous, definite, and coherent in their relations, that this compound clustering is carried to the greatest extent. Along with the ability to form that complex consciousness of lights, shades, and colours, joined in relative positions, which constitute a man as present to sight, there goes the ability to form a consciousness of two men in a definite and coherent relation of position—there goes the ability to form a consciousness of a crowd of such men; nay, two or more such crowds may be mentally combined. The aggregate of definitely-related visual feelings known as a house, itself aggregates with others such to form the consciousness of a street, and the streets to form the consciousness of a town. Though the compound clustering of visual feelings in sequence is not so distinct or so strong, it is still very marked. Numerous complicated images produced by objects seen in succession, hang together in consciousness with considerable tenacity. There is little, if any, clustering of clusters among the simultaneous auditory feelings. But among the successive auditory feelings there are definite and coherent combinations of groups with groups. The fused set of sounds we call a word, unites with many others such into a sentence. In some minds these clusters of clusters of successive sounds again cluster very definitely and coherently: many successive sentences are, as we say, accurately remembered. And similarly, musical phrases will cling together into a long and elaborate melody. Among the tactual feelings this compound clustering is scarcely traceable, either in space or time; and there is not the remotest approach to it in the olfactory and gustatory feelings.

For form's sake it is needful to say that these higher degrees of mental composition are entirely wanting among the internally-initiated feelings. Only among those which accompany muscular motion is there any approach to it; and here the compound clustering, like the simple clustering, entails progressing unconsciousness.

§ 72. One more kindred trait of composition must be set down. Thus far we have observed only the degrees of mutual limitation, of cohesion, and of complex combining power, among feelings within each order. It remains to observe the extent to which feelings of one order enter into relations with those of another, and the consequent amounts of their mutual limitations and of their combining powers. To trace out these at all fully would carry us into unmanageable detail. We must confine ourselves to leading facts.

Feelings of different orders do not limit one another as clearly as feelings of the same order do. The clustered colours produced by an object at which we look are but little interfered with by a sound: the sound does not put any appreciable boundary to them in consciousness, but serves merely to diminish their dominance in consciousness. Neither the combined noises which make up a conversation at table, nor the impressions received through the eyes from the dishes on the table, are excluded from the mind by the accompanying tactual feelings and tastes and smells, as much as colours are excluded by colours, sounds by sounds, tastes by tastes, or one tactual feeling by another. Of sensations arising within the body, and still more of emotions, it may be said that, unless intense, they disturb but slightly the sensations otherwise arising. It would almost seem as though a sensation of colour, a sensation of sound, and a pleasurable emotion produced by the sound, admit of being superposed in consciousness with but little mutual obscuration. Doubtless in most cases two simple feelings, or two clustered feelings of different orders, put bounds to one another in time if not in space: there is an extremely rapid extrusion of each by the other rather than a continuous presence of either. But it is manifest that these alternating extrusions, partial or complete, by feelings of different orders, are less distinct than the extrusion of one another by feelings of the same order.

It is a correlative truth that feelings of different orders cohere with one another less strongly than do feelings of the same order. The impressions which make up the visual consciousness of an object, hang together more firmly than the group of them does with the group of sounds making up the name of the object. The notes composing a melody have a stronger tendency to drag one another into consciousness than any one, or all of them, have to drag into consciousness the sights along with which they occurred: these last may or may not cohere with them; but the following of one note by the next is often difficult to prevent. Similarly, though there is considerable cohesion between the visual sensations produced by an orange and the taste or smell of the orange, yet it is quite usual to have a visual consciousness of an orange without its taste or its smell arising in consciousness; while it is scarcely possible to have before the mind one of its apparent characters unaccompanied by other apparent characters.

A further fact of moment must be added. The feelings of different orders which enter into definite relations and cohere most strongly, are those among which there is a predominance of the relational elements; and there is an especial facility of combination between those feelings of different orders which are respectively held together by relations of the same order. Thus the co-existent visual feelings, most relational of all, enter into very definite and coherent relations with co-existent tactual feelings. To the group of lights and shades an object yields to the eyes, there attaches itself very strongly the group of impressions produced by touching and grasping the object. Next in order of strength are the connections between sensations received through the eyes and those received through the ears; or rather—between clusters of the one and clusters of the other. But though the feelings clustered in co-existence that form the visual consciousness of anything, are linked with much strength to the feelings clustered in sequence that form the consciousness of its name; yet, probably because the feelings forming the one cluster not only differ in kind from those forming the other but are held together by relations of a different order, the cohesion of the two clusters is not so strong. As we descend towards the unrelational feelings we find that this combining power of class with class decreases. Between tastes and smells and certain visceral sensations, such as hunger and nausea, there is, indeed, a considerable aptitude to cohere. But after admitting exceptions, it remains true on the average that the extremely-unrelational states of consciousness of different orders, connect but feebly with one another and with the extremely-relational states of consciousness.

§ 73. Thus far we have proceeded as though Mind were composed entirely of the primary or vivid feelings, and the relations among them; ignoring the secondary or faint feelings. Or if, as must be admitted, there has been a tacit recognition of these secondary feelings in parts of the foregoing sections which deal with the relations and cohesions of feelings in sequence (since in a sequence of feelings those which have passed have become faint, and only the one present is vivid); yet there has been no avowed recognition of them as components of Mind different from, though closely allied with, the primary feelings. We must now specially consider them and the part they play.

The cardinal fact to be noted as of co-ordinate importance with the facts above noted, is that while each vivid feeling is joined to, but distinguished from, other vivid feelings, simultaneous or successive, it is joined to, and identified with, faint feelings that have resulted from foregoing similar vivid feelings. Each particular colour, each special sound, each sensation of touch, taste, or smell, is at once known as unlike other sensations that limit it in space or time, and known as like the faint forms of certain sensations that have preceded it in time—unites itself with foregoing sensations from which it does not differ in quality but only in intensity.

On this law of composition depends the orderly structure of Mind. In its absence there could be nothing but a perpetual kaleidoscopic change of feelings—an ever-transforming present without past or future. It is because of this tendency which vivid feelings have severally to cohere with the faint forms of all preceding feelings like themselves, that there arise what we call *ideas*. A vivid feeling does not by itself constitute a unit of that aggregate of ideas entitled knowledge. Nor does a single faint feeling constitute such a unit. But an idea, or unit of knowledge, results when a vivid feeling is assimilated to, or coheres with, one or more of the faint feelings left by such vivid feelings previously experienced. From moment to moment the feelings that constitute consciousness segregate—each becoming fused with the whole series of others like itself that have gone before it; and what we call knowing each feeling as such or such, is our name for this act of segregation.

The process so carried on does not stop with the union of each feeling, as it occurs, with the faint forms of all preceding like feelings. Clusters of feelings are simultaneously joined with the faint forms of preceding like clusters. An idea of an object or act is composed of groups of similar and similarly-related feelings that have arisen in consciousness from time to time, and have formed a consolidated series of which the members have partially or completely lost their individualities.

This union of present clustered feelings with past clustered feelings is carried to a much greater degree of complexity. Groups of groups coalesce with kindred groups of groups that preceded them; and in the higher types of Mind, tracts of consciousness of an excessively composite character are produced after the same manner.

To complete this general conception it is needful to say that as with feelings, so with the relations between feelings. Parted so far as may be from the particular pairs of feelings and pairs of groups of feelings they severally unite, relations themselves are perpetually segregated. From moment to moment relations are distinguished from one another in respect of the degrees of contrast between their terms and the kinds of contrast between their terms; and each relation, while distinguished from various concurrent relations, is assimilated to previously-experienced relations like itself. Thus result *ideas* of relations as those of strong contrast or weak contrast, of descending intensity or ascending intensity, of homogeneity of kind or heterogeneity of kind. Simultaneously occurs a segregation of a different species. Each relation of co-existence is classed with other like relations of co-existence and separated from relations of co-existence that are unlike it; and a kindred classing goes on among relations of sequence. Finally, by a further segregation, are formed that consolidated abstract of relations of co-existence which we know as Space, and that consolidated abstract of relations of sequence which we know as Time. This process, here briefly indicated merely to show its congruity with the general process of composition, cannot be explained at length: the elucidation must come hereafter.

§ 74. And now having roughly sketched the composition of Mind—having, to preserve clearness of outline, omitted details and passed over minor qualifications; let me go on to indicate the essential truth which it is a chief purpose of this chapter to bring into view—the truth that the method of composition remains the same throughout the entire fabric of Mind, from the formation of its simplest feelings up to the formation of those immense and complex aggregates of feelings which characterize its highest developments.

In the last chapter we saw that what is objectively a wave of molecular change propagated through a nerve-centre, is subjectively a unit of feeling, akin in nature to what we call a nervous shock. In one case we found conclusive proof that when a rapid succession of such waves yield a rapid succession of such units of feeling, there results the continuous feeling known as a sensation; and that the quality of the feeling changes when these waves and corresponding units of feeling recur with a different rapidity. Further, it was shown that by unions among simultaneous series of such units recurring at unlike rates, countless other seemingly-simple sensations are produced. And we inferred that what unquestionably holds among these primary feelings of one order, probably holds among primary feelings of all orders. To what does this conclusion amount, expressed in another way? It amounts to the conclusion that one of these feelings which, as introspectively contemplated, appears uniform, is really generated by the perpetual assimilation of a new pulse of feeling to pulses of feeling immediately preceding it: the sensation is constituted by the linking of each vivid pulse as it occurs, with the series of past pulses that were severally vivid but have severally become faint. And what, otherwise stated, is the conclusion that compound sensations result from unions among different concurrent series of such pulses? It is that while the component pulses of each series are, as they occur, severally assimilated to, or linked with, preceding pulses of their own kind, they are also severally combined in some relation with the pulses of concurrent series; and the compound sensation so generated is known as different from other compound sensations of the same order, by virtue of some speciality in the relations among the concurrent series.

Consider now, under its most general form, the process of composition of Mind described in foregoing sections. It is no other than this same process carried out on higher and higher platforms, with increasing extent and complication. As we have lately seen, the feelings called sensations cannot of themselves constitute Mind, even when great numbers of various kinds are present together. Mind is constituted only when each sensation is assimilated to the faint forms of antecedent like sensations. The consolidation of successive units of feeling to form a sensation, is paralleled in a larger way by the consolidation of successive sensations to form what we call a knowledge of the sensation as such or such—to form the smallest separable portion of what we call thought, as distinguished from mere confused sentiency. So too is it with the relations among those feelings that occur together and limit one another in space or time. Each of these relations, so long as it stands alone in experience with no antecedent like relations, is not fully cognizable as a relation: it assumes its character as a component of intelligence only when, by recurrence of it, there is produced a serial aggregate of such relations. Observe further that while each special sensation is raised into a proximate constituent of simple thought only by being fused with like predecessors, it becomes a proximate constituent of compound thought by simultaneously entering into relations of unlikeness with other sensations which limit it in space or time; just as we saw that the units or pulses that form simple sensations by serial union with their kind, may simultaneously help to form complex sensations by entering into relations of difference with units of other kinds.

The same thing obviously holds of the relations themselves, that exist between these unlike sensations. And thus it becomes manifest that the method by which simple sensations, and the relations among them, are compounded into states of definite consciousness, is essentially analogous to the method by which primitive units of feeling are compounded into sensations.

The next higher stage of mental composition shows us this process repeating itself. The vivid cluster of related sensations produced in us by a special object, has to be united with the faint forms of clusters like it that have been before produced by such objects. What we call knowing the object, is the assimilation of this combined group of real feelings it excites, with one or more preceding ideal groups which objects of the same kind once excited; and the knowledge is clear only when the series of ideal groups is long. Equally does this principle hold of the connexions, static and dynamic, between each such special cluster and the special clusters generated by other objects. Knowledge of the powers and habits of things, dead and living, is constituted by assimilating the more or less complex relations exhibited by their actions in space and time with other such complex relations. If we cannot so assimilate them, or parts of them, we have no knowledge of their actions.

That the same law of composition continues without definite limit through tracts of higher consciousness, formed of clusters of clusters of feelings held together by relations of an extremely involved kind, scarcely needs adding.

§ 75. How clearly the evolution of Mind, as thus traced through ascending stages of composition, conforms to the laws of Evolution in general, will be seen as soon as it is said. We will glance at the correspondence under each of its leading aspects.

Evolution is primarily a progressing integration; and throughout this chapter, as well as the last, progressing integration has thrust itself upon us as the fundamental fact in mental evolution. We came upon it quite unexpectedly in the conclusion that a sensation is an integrated series of nervous shocks or units of feeling; and in the further conclusion that by integration of two or more such series, compound sensations are formed. We have lately seen that by an integration of successive like sensations, there arises the knowledge of a sensation as such or such; and that each sensation as it occurs, while thus integrated with its like, also unites into an aggregate with other sensations that limit it in space or time. And we have similarly seen that the integrated clusters resulting, enter into higher integrations of both these kinds; and so on to the end. The significance of these facts will be appreciated when it is remembered that the tracts of consciousness in which integration is undecided, are tracts of consciousness hardly included in what we commonly think of as Mind; and that the tracts of consciousness presenting the attributes of Mind in the highest degree, are those in which the integration is carried furthest. Hunger, thirst, nausea, and visceral feelings in general, as well as feelings of love, hatred, anger, &c., which cohere little with one another and with other feelings, and thus integrate but feebly into groups, are portions of consciousness that play but subordinate parts in the actions we chiefly class as mental. Mental actions, ordinarily so called, are nearly all carried on in terms of those tactual, auditory, and visual feelings, which exhibit cohesion, and consequent ability to integrate, in so conspicuous a manner. Our intellectual operations are indeed mostly confined to the auditory feelings (as integrated into words) and the visual feelings (as integrated into impressions and ideas of objects, their relations, and their motions). After closing the eyes and observing how relatively-immense is the part of intellectual consciousness that is suddenly shorn away, it will be manifest that the most developed portion of perceptive Mind is formed of these visual feelings which cohere so rigidly, which integrate into such large and numerous aggregates, and which re-integrate into aggregates immensely exceeding in their degree of composition all aggregates formed by other feelings. And then, on rising to what we for convenience distinguish as rational Mind, we find the integration taking a still wider reach.

The ascending phases of Mind show us no less conspicuously, the increasing heterogeneity of these integrated aggregates of feelings. In the last chapter, we saw how sensations that are all composed of units of one kind, are rendered heterogeneous by the combination and re-combination of such units in multitudinous ways. We have lately seen that the portions of consciousness occupied by the internal bodily feelings and by the emotions, are, as judged by introspection, relatively very simple or homogeneous: thirst is not made up of contrasted parts, nor can we separate a gust of passion into many distinguishable components. But on passing upwards to intellectual consciousness, there meets us an increasing variety of kinds of feelings present together. When we come to the auditory feelings, which play so important a part in processes of thought, we find that the groups of them are formed of many components, and that those groups of groups used as symbols of propositions are very heterogeneous. As before however with integration, so here with heterogeneity, a far higher degree is reached in that consciousness formed of visual feelings, which is the most developed part of perceptive Mind. And much more heterogeneous still are those tracts of consciousness distinguished as ratiocinative tracts, in which the multiform feelings given us by objects through eyes, ears, and tactual organs, nose, and palate, are formed into conceptions that answer to the objects in all their attributes, and all their activities.

With equal clearness does Mind display the further trait of Evolution—increase of definiteness. Both the centrally-initiated feelings and the internal peripherally-initiated feelings, which play so secondary a part in what we understand as Mind, we found to be very vague—very imperfectly limited by one another. Contrariwise, it was shown that the mutual limitations are decided among those peripherally-initiated feelings which, arising on the outer surface, enter largely into our intellectual operations; and that the visual feelings, which enter by far the most largely into our intellectual operations, are not only by far the sharpest in their mutual limitations, but form aggregates that are much more definitely circumscribed than any others, and aggregates between which there exist relations much more definite than those entered into by other aggregates.

Thus the conformity is complete. Mind rises to what are universally recognized as its higher developments, in proportion as it manifests the traits characterizing Evolution in general (*First Principles*, §§ 98—145). A confused sentiency, formed of recurrent pulses of feeling having but little variety of kind and but little combination, we may conceive as the nascent Mind possessed by those low types in which nerves and nerve-centres are not yet clearly differentiated from one another, or from the tissues in which they lie. At a stage above this, while yet the organs of the higher senses are rudimentary, and such nerves as exist are incompletely insulated, Mind is present probably under the form of a few sensations, which, like those yielded by our own viscera, are simple, vague, and incoherent. And from this upwards, the mental evolution exhibits a differentiation of these simple feelings into the more numerous kinds which the special senses yield; an ever-increasing integration of such more varied feelings with one another and with feelings of other kinds; an ever-increasing multiformity in the aggregates of feelings produced; and an ever-increasing distinctness of structure in such aggregates. That is to say, there goes on subjectively a change "from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity;" parallel to that redistribution of matter and motion which constitutes Evolution as objectively displayed.

§ 76. The correspondences between these views of mental composition and the general truths respecting nervous structure and nervous functions set forth in the last part, must be briefly indicated.

Speaking generally, feelings and the relations between feelings, correspond to nerve-corpuscles and the fibres which connect nerve-corpuscles; or rather, to the molecular changes of which nerve-corpuscles are the seats, and the molecular changes transmitted through fibres. The psychical relation between two feelings, answers to the physical relation between two disturbed portions of grey matter, which are put in such direct or indirect communication that some discharge takes place between them.

The fact that, as elements of consciousness, the relations between feelings are very short in comparison with the feelings they unite, has thus its physiological equivalent in the fact that the transmission of a wave of change through a nerve-fibre, is very rapid in comparison with the transformation it sets up in a nerve-centre. If we consider each such transformation to be physically that which psychically we consider a unit of feeling, then, remembering its appreciable duration, we may understand how it happens that when the waves of molecular change brought by an in-coming nerve-fibre exceed a certain rate of recurrence, the transformation set up each lasts till the next commences; and hence the corresponding units of feeling become fused into a continuous feeling or sensation.

We have seen that predominance of the relational element of Mind, characterizes the peripherally-initiated tracts of consciousness which external objects produce. Between this fact and the facts of nervous structure, there is an obvious agreement. Take the case of the eye. The retina being an area formed of an immense number of sensitive elements, close to, but separate from, one another, and having each an independent centripetal fibre; it results that the relations that may be established between each one and all the others are enormous in number, and that enormous numbers of relations may be established between simultaneously-excited clusters of them and other simultaneously-excited clusters. The sharpness of mutual limitation of the feelings and clusters of feelings here initiated, is also clearly due to these same structural peculiarities; as are also their rigid cohesions and extensive integrations. Without naming the intermediate cases, it will suffice if we pass to the other extreme and observe how, in the visceral nervous system, whence come feelings that are so simple, so indefinite, and so incoherent, there is an absence of the appliances which secure independent excitements of adjacent nerve-terminations.

A further harmony of the same order may be noted. The relational element of Mind, as shown in mutual limitation, in strength of cohesion, and in degree of clustering, is greater between feelings of the same order than between feelings of one order and those of another. This answers to the fact that the bundles of nerve-fibres and clusters of nerve-vesicles belonging to feelings of one order, are combined together more directly and intimately than they are with the fibres and vesicles belonging to feelings of other orders. Similarly, it holds among feelings of different orders, that the readiness to enter into relations is much greater between those arising in the higher sense-organs, which have nervous centres closely connected, than between them and the visceral feelings which arise in parts of the nervous system that communicate but indirectly with the higher centres. Even an anomaly appears thus explicable. That such unrelational feelings as smells have exceptional powers of calling up remembrances of past scenes, is probably due to the fact that the olfactory centres are outgrowths from the cerebral hemispheres.

We have seen that the development of Mind is fundamentally an increasing integration of feelings on successively-higher stages, along with which there go increasing heterogeneity and definiteness; and these traits answer to traits in the evolution of the nervous system before contemplated. For we found that along with growing distinctness and multiformity of structure, there is throughout an advancing integration of structure as well as of mass. (See § 8.)

One more correspondence of moment may be pointed out —a correspondence that replaces a supposed discordance. The most developed and conspicuous part of Mind chiefly occupies men's attention; and hence they speak of Mind and Intelligence as equivalents. As hinted in § 7, even physiologists, intending to ignore all pre-conceptions, have been led into difficulties of interpretation by inadvertently setting out with this belief as their postulate. But Mind is not wholly, or even mainly, Intelligence. We have seen that it consists largely, and in one sense entirely, of Feelings. Not only do Feelings constitute the inferior tracts of consciousness, but Feelings are in all cases the materials out of which, in the superior tracts of consciousness, Intellect is evolved by structural combination. Everywhere Feeling is the substance of which, where it is present, Intellect is the form. And where Intellect is not present, or but little present, Mind consists of feelings that are unformed or but little formed. Intellect comprehends only the relational elements of Mind; and to omit Feelings is to omit the terms between which the relations exist. The recognition of this truth saves us from the error of looking for a regular correspondence between the development of the nervous system and the degree of Intelligence. As in § 7 we saw that the size of the nervous system varies partly as the quantity of motion evolved, and partly as the complexity of that motion; so here we see that the size of the nervous system varies partly as the quantity of Feeling (which has a general relation to the quantity of motion) and partly as the degree of Intellect (which has a general relation to the complexity of the motion). And thus interpreting the facts, supposed anomalies disappear.

CHAPTER III.

THE RELATIVITY OF FEELINGS.

§ 77. Mind being composed of Feelings and the Relations between Feelings, and the aptitudes of Feelings for entering into Relations varying with their kinds, the Relativity of Feelings is an expression applicable, in one sense, to certain of the purely subjective phenomena described in the last chapter. But it is here to be understood in quite a different sense. Having contemplated Feelings in their relations to one another as components of consciousness, we have now to contemplate them in their relations to the things beyond consciousness by which they are produced.

Moreover, the things beyond consciousness here to be considered, are not the nerve-disturbances which are the physical sides of what we call feelings on their psychical sides: already, in the chapter on Æstho-Physiology, the relations between the subjective and objective faces of nervous changes have been described. Our present inquiry is into the nature of the connexions between feelings, and forces existing outside the organism. To treat of these without going over any ground before traversed is difficult; since an external action being related to a feeling only through an intermediate nervous change, the intermediation cannot well be left out of sight. Occasional brief repetitions must therefore be excused.

It should be further premised that we are here concerned mainly with peripherally-initiated feelings which have external origins; or rather, with those primary or vivid forms of them which we call real, in contradistinction to the secondary or faint forms we call ideal.

§ 78. The general truth, familiar to all students of Psychology, which it is the object of this chapter to present under its many aspects, is that though internal feeling habitually depends on external agent, yet there is no likeness between them either in kind or degree. The connexion between objective cause and subjective effect is conditioned in ways extremely complex and variable—ways which we will proceed to consider seriatim.

We shall find that each set of conditions so modifies the connexion between objective cause and subjective effect as to determine the qualitative character of the effect. In other words, the same agent produces feelings of quite unlike natures according to the circumstances under which it acts.

We shall further see that, besides this qualitative unlikeness, there is a quantitative unlikeness. Between the outer force and the inner feeling it excites, there is no such correlation as that which the physicist calls equivalence—nay, the two do not even maintain an unvarying proportion. Equal amounts of the same force arouse different amounts of the same feeling, if the circumstances differ. Only while all the conditions remain constant is there something like a constant ratio between the physical antecedent and the psychical consequent.

§ 79. Were I not bound to enumerate all aspects of this relativity, it would be needless to say that the connexion between the outer agent and the inner feeling generated by it, depends on the structure of the species.

Obviously the forms of sensation that can be roused in the consciousness of a creature, are primarily determined by the peripheral organs with which its type is endowed. This is so even with the most general of the sensations—that of Touch. A Crustacean, everywhere enclosed in a hard exoskeleton, can have no such tactual impressions as those which are possible to a soft-skinned animal. The impressions received from the ends of its limbs and claws when they come in contact with external objects, may be compared to those which a man receives from poking objects with the end of his walking-stick. Still more manifestly are the special sensations dependent for their qualities on the presence of special sense-organs. Take the auditory sensations. Various aquatic creatures that have no developed organs of Hearing, are nevertheless affected by those vibrations which to creatures better endowed are sonorous. When such vibrations are propagated through their medium, they contract themselves, or they withdraw into their shells if they have them. We may reasonably assume that what they feel is a jar somewhat resembling the jar received by the hand from a vibrating musical instrument. But in any case, the quality of the feeling excited in these lower animals by sonorous waves, is wholly unlike the quality of the feeling which such waves excite in higher animals.

That, qualities being alike, the quantities of the feelings produced by given agents vary with the specific structures, is an equally familiar truth. In a bird or mammal having eyes that fit it for nocturnal habits, the sensation aroused by a faint light, is much greater than is aroused by it in a diurnal bird or mammal; and the light which gives to a diurnal creature a moderate amount of sensation suffices to dazzle the nocturnal creature by its excess. Similarly with the olfactory feelings. An odour which has no appreciable effect on the consciousness of a man, has a very marked effect on the consciousness of a dog. Even varieties of dogs, as the greyhound and the beagle, yield us evidence of decided quantitative differences between the mental changes caused by the same odour.

These few instances warrant us in suspecting that in no two species does a given amount of a given outer agent excite exactly the same kind and quantity of feeling.

§ 80. This apparently hasty generalization is justified by the generalization to which we come next; namely, that within the same species the relation between objective cause and subjective effect varies both qualitatively and quantitatively with the constitution—varies, that is, with the individual structure.

That peculiarity of vision discovered in himself by Dalton, and sometimes named after him, yields an instance of qualitative difference. To those organized as he was, the visible world does not present all the various feelings of colour that it does to mankind in general. Sensations which to others seem strongly contrasted, as red and green, seem to them the same. Whence we must conclude that certain etherial undulations produce in such persons feelings unlike those they produce in other persons. From sentient states excited through the ears, may be drawn another illustration. Aërial pulses recurring at the rate of sixteen per second are perceived by some as separate pulses; but by some they are perceived as a tone of very low pitch. Similarly at the other extreme. Vibrations exceeding thirty thousand per second, are inaudible through certain ears; while through ears that are, as we may suppose, of somewhat unlike structures, these rapid vibrations are known as an excessively acute sound.

Quantitative differences of sensation that are caused by differences of individual organization, every one observes. All orders of sensations exemplify them. Here are instances from each. Thick-skinned persons are insensible to tactual impressions which thin-skinned persons clearly feel; and there are persons by whom minute unlikenesses of surface are so distinctly perceived that they are employed to judge of commodities, such as raw silk, by handling them. How amounts of flavour quite inappreciable by some are readily appreciable by others, the dinner-table constantly reminds us. And that there are professional tasters, shows that the gustatory feeling produced by a given quantity of sapid substance, is, in exceptional organizations, much greater than usual. With smells it is the same. There are those to whom quite delicate perfumes seem of overpowering strength. And there are those to whom odours usually felt to be disgusting in the extreme, are scarcely perceptible. Constitutional differences in quickness of hearing, sometimes marked between persons of the same race, are more marked between persons of different races. By putting his ear to the ground a savage hears sounds inaudible by a civilized man. The like holds with visual sensitiveness. The Bushman is impressible by changes in the field of view which do not impress the European. And such tests as occur in the telescopic search for minute stars, show that, in the same race, the amount of light which excites a distinct feeling in one person, excites no feeling in another.

Thus we may make wider the startling inference drawn in the last section. Besides concluding that in no two species are the subjective effects produced by given objective actions absolutely alike, qualitatively and quantitatively; we may conclude that they are absolutely alike in no two individuals of the same species.

§ 81. Whatever there may seem of excess in this statement will disappear when we remember that even in the same individual the quantity, if not the quality, of the feeling excited by an external agent constant in kind and degree, varies according to the constitutional state.

Of qualitative variations we have but vague and indirect evidence. Still the experiences of invalids yield reason to suspect that they occur. There are abnormal states of the nervous system during which illusive sensations trouble the patient. The consciousness of a disagreeable smell which is one of the premonitory symptoms of an epileptic fit, may be named as an instance. And if feelings of purely subjective origin, so strong as to be mistaken for feelings of objective origin, may arise from extreme nervous derangements, it is reasonably inferable that smaller nervous derangements will often arouse vague subjective states which may mingle with, and qualify, the feelings objectively originated.

The quantitative variations which variations of constitutional state entail among the feelings produced by equal external agents, are very familiar. As before, some are consequent on derangements of health and some on advancing years. In certain conditions of nervous irritability, sounds of ordinary strength seem intolerably loud; daylight becomes unbearable from the excess of visual feeling it causes; and even the skin becomes unduly sensitive: there is what is called hyper-æsthesia. Contrariwise, there are deviations from health characterized by an anæsthesia allied to that artificially caused—a state of comparative indifference to amounts of external stimuli which commonly arouse much feeling. How along with decline of vigour in old age there goes an increasing anæsthesia of one or more kinds, we have daily proof. There is dimness of sight; there is dulness of hearing; there is often obtuseness of taste.

Thus, besides seeing that the subjective effect produced by each objective cause varies with the structure of the species, and varies with the structure of the individual of the species, we see that it varies with the constitutional state of the individual—often in a marked degree. Very possibly the ratio is never twice the same; but always differs infinitesimally, if not appreciably.

§ 82. The kind and degree of effect which an external physical stimulus produces on the psychical state, depends also on the part of the organism subject to it. Equal quantities of the same force excite feelings widely unlike, qualitatively and quantitatively, according to the structures of the peripheral organs on which they fall.

The qualitative differences we recognize so much as matters of course that we forget their significance. Here, however, they must not be passed over. Many kinds of matter which, when applied to the skin at large, cause only sensations of touch, cause, when applied to the tongue, sensations of touch and taste; or, if they are kinds of matter having the tastes we call pungent, they arouse in the skin sensations of heat or tingling. Similarly with volatile substances. A whiff of ammonia coming in contact with the eyes, produces a smart; getting into the nostrils, excites the consciousness we describe as an intolerably strong odour; being condensed on the tongue, generates an acrid taste; while ammonia applied in solution to a tender part of the skin, makes it burn, as we say. The feeling caused by sonorous undulations, already adverted to as varying with the structure of the species, must be named here also as varying with the structure of the part affected. A vibrating tuning-fork touched with the fingers, gives them a sense of jar; held between the teeth, it gives this same sense to the parts in which they are imbedded, while by communication through the bones of the skull, its vibrations so affect the auditory apparatus as to awaken a consciousness of sound—a consciousness which alone results if the tuning-fork does not touch the body. The different sensations excited by etherial undulations on the unmodified integument and on those modified portions of it which constitute eyes (*Principles of Biology*, § 295) yield further illustrations. The Sun's rays falling on the hand cause a sensation of heat but no sensation of light; and falling on the retina cause a sensation of light but no sensation of heat. As Professor Tyndall has proved by experiment on himself, the retina is insensible to heat-rays of considerable concentration.

That the relation between an outer force and the inner feeling it arouses, varies quantitatively according to the part of the body acted upon, there are many proofs, of which one or two will suffice. The arched under-surface of the foot experiences an intense sensation of tickling from a gentle touch which generates a much feebler sensation of this kind elsewhere. Conversely, the thick skin of the heel bears with comparatively little pain the long-continued pressure of a hard prominence which would be intolerable to the back of the hand. The feelings caused by exposing different parts of the skin to the same heat, are not in most cases conspicuously unlike in degree; but there is one case in which they are. When drinking a liquid the heat of which is quite bearable by that part of the upper lip usually immersed, it may be observed that if the lip is accidentally dipped deeper, so as to immerse a little of the outer skin, a sensation of scalding results.

We find, then, that the same external agent acting on different peripheral organs, generates states of consciousness which have in many cases no likenesses of kind whatever, and have in other cases immense unlikenesses of degree.

§ 83. The state of the part affected, as well as its structure, has a share in determining the relation between outer agent and inner feeling. Already in the chapter on Æstho-Physiology, it has been shown that the ratio borne by the change set up in a nerve-termination to the feeling elicited, varies with the local conditions. Obviously this involves a concomitant variation in the ratio between the amount of external force which initiates the nervous change, and the amount of feeling that eventually results. It will suffice to recall the several causes of the variation.

The temperature of the part is one of them. Between the state of local insensibility produced by excessive cold, and the state of sensibility accompanying natural warmth, there are states showing all gradations in the proportion which the incident force bears to the feeling called forth.

Local anæmia affects this proportion by diminishing the quantity of sensation which a given amount of outer action generates; and local hyperæmia, by increasing it—often extremely. Hyperæmia, however, in certain cases (possibly by putting an obstacle between the outer agent and the nerves to be affected) decreases the amount of feeling generated; as in the partial or complete loss of taste and smell caused by a bad cold.

The condition of the structures concerned as modified by previous discharge of their functions, is a further cause of variation in the ratio between the objective actions and the subjective effects due to them. Sensory organs worn by strong excitements recently undergone, require greater external forces to arouse the same amounts of internal feelings. This is so with touches, tastes, smells, as well as visual and auditory impressions.

One more cause of variation, occurring in a special class of cases, must be added. The sensation that follows contact with matter hotter or colder than the body, depends less on the temperature of the matter than on the contrast between its temperature and that of the body. On going into a warm bath or into cold water, the heat or the cold seems greater than it does after a short interval, during which the thermal state of the skin has approximated to that of the water. More striking still is the evidence yielded by cases in which the same tepid water feels either warm or cold according to the temperature of the hand put into it; nay, in which it feels both warm and cold to the two hands, if one has been much heated and the other much cooled.

§ 84. Yet another general fact remains. The relative motions of subject and object, modify, both qualitatively and quantitatively, the relations between incident forces and evoked feelings.

The instance of qualitative modification most easily observed, is that produced in the pitch of a sound by the movement of the sounding body towards, or away from, the auditor. If, as an express train passes through a railway-station, the whistle happens to be going, the tone heard by each person in the station, changes from a higher to a lower at the moment the engine goes by him. A still more marked change is perceivable if the auditor, seated in a train travelling with considerable speed in one direction, is passed by a whistling engine travelling rapidly in the opposite direction. Under such circumstances I have observed, at the moment of passing, a fall in the pitch of the note amounting to a major third or even a fourth. How this is due to an alteration in the number of aërial pulses reaching the ear in a given time, need not here be explained at length. It concerns us only to note that the quality of the feeling produced by a sounding body is not the same when the body is approaching or receding as when stationary; and that the quality of the feeling changes with every change in the rate of approach or recession. A remarkable illustration of analogous nature, has been disclosed by inquiries respecting the qualities of the lights radiated by different stars. Some years since it was suggested that possibly the apparent colours of the stars are determined by their motions towards, or away from, the Earth at various velocities; and though this supposition has not turned out to be true, yet a truth akin to it has been discovered. Though to the naked eye, the quality of the light emanating from each star is not appreciably affected by the star's velocity of approach to, or recession from, us; yet, as examined through the spectroscope, its quality proves to be thus affected. Mr. Huggins has recently shown that the spectrum of Sirius differs from the spectrum he would yield were he stationary relatively to us; and differs in such way as to show that he is moving away from us at a rate of more than two millions of miles per day. Hence, in a degree appreciable under certain conditions, the nature of the feeling excited by luminiferous undulations, varies according to the relative motion of the observer and the body emitting them.

Of quantitative variations arising from relative motion, we have a familiar instance in the different feelings of heat or of cold produced in us by surrounding media, when we are at rest and when we move. In a bath above 100°, the water seems hotter to a limb that stirs than to one that is stationary; and every bather knows how much colder running water of a given temperature feels than still water of the same temperature—a contrast that becomes very great when the velocity of the water is much raised, as in a douche. Similarly with the air. A greater chill is felt by those who, instead of standing still, are exposed in a carriage to "the wind of their own speed." Though the explanation of these differences is, that the medium in contact with the skin is continually changed in the one set of cases and not in the other, yet it remains true that the sensation varies in intensity as the relative motion of the medium varies.

§ 85. Thus far we have limited our attention to the feelings excited by external things acting on the organism. We must not, however, pass over the feelings which accompany actions of the organism on external things. Though here the relation between subjective and objective changes does not obviously vary qualitatively, it varies very much quantitatively.

If, in muscular action, there took place a transformation of the feeling of muscular effort into an equivalent of mechanical effect; then a given amount of such feeling would always generate the same amount of such effect, through whatever muscles expended. But the fact is quite otherwise. The conscious exercise of force required when a stone weight is lifted by the little finger, far exceeds that required when the stone weight is grasped in the hand, and lifted by the arm. Or again, the gymnastic feat of raising the body up a ladder hand over hand, implies a much higher degree of the subjective state we call exertion than is implied by climbing up the ladder in the usual way. Clearly, therefore, a given amount of feeling gives rise to an amount of molar motion which is large or small according to the muscles used. This relation is also dependent on age. The sense of effort which a child experiences in raising a weight, greatly exceeds in intensity the sense of effort it will experience in raising the same weight by the same muscles twenty years afterwards. At maturity, a like amount of sensation is the correlate of an increased amount of produced motion. Similarly, this relation varies quantitatively as the constitutional state varies. After a prostrating illness, the feeling of strain that accompanies the raising of a limb, is as great as that which in health accompanies a considerable feat of strength.

§ 86. Were it not that already as much space as can be afforded has been occupied, it would be well here to illustrate the ways in which both the peripherally-initiated feelings that arise in internal organs and the centrally-initiated feelings or emotions, have also their several forms of relativity. But it must suffice just to indicate these extensions of the general truth that has been set forth.

For present purposes we may fitly limit ourselves to the relativity of those peripherally-initiated feelings directly traceable to environing agencies. Their relativities we find to be of manifold kinds. The quality and the quantity of the sensation produced by a given amount of a given external force, vary not only with the structure of the organism, specific and individual, as well as the structure of the part affected, but also with the age, the constitutional state, the state of the part as modified by temperature, circulation, and previous use, and even with the relative motion of subject and object. Thus we may count up nine different causes which affect qualitatively or quantitatively or both, the relation between the exciting physical agent and the produced psychical modification. These different causes co-operate in ever-changing proportions. And when we remember that any change in any one of them results in some alteration in the kind or degree of feeling aroused, we become strongly impressed with the truth that subjective consciousness, determined as it is wholly by subjective nature, state, and circumstances, is no measure of objective existence.

Indeed, the primitive belief that redness exists as such out of the mind, and that sound possesses apart from ourselves that quality which it has to our perception, is thus rendered as hard for the psychologist to entertain as its opposite is hard to entertain for the uncultivated. After learning that when a tumbler is struck the blow causes in it a change of form, instantly followed by an opposite change of form, after which there recurs the first form, and so on—after perceiving that each of these rhythmical changes of form gives an impact to substances in contact with the tumbler, generating visible waves on the surface of its contained liquid, and waves having like periods in the surrounding air—when it has been proved to us that the feeling of tone results only when such mechanical oscillations of adjacent matter recur with a certain speed, and varies in quality according to the speed—when, further, we find that these mechanical oscillations produce this feeling only when they fall on a particular structure, and that, when they fall on other structures, they produce feelings of totally unlike kinds; we become fully convinced that the form of objective action we call sound, has not the slightest kinship in nature to the sensation of sound which it arouses in us. Similarly with undulations of the etherial medium. Now that we know heat and light to be nearly-allied forms of insensible motion, which may arise by transformation of sensible motion and may be re-transformed into it, we are convinced that among the outer actions which arouse in us the feelings of light, heat, and sensible motion, there can be no such intrinsic differences as among the feelings we know by these names; and that hence these feelings cannot be like them. There follows irresistibly the conclusion that the same holds of tastes and smells—that a bitter flavour implies in the substance yielding it nothing like what we call bitterness, and that there is no intrinsic sweetness in the exhaled matter which we distinguish as a sweet odour; but that, in these cases as in the others, the objective action which sets up the subjective state, no more resembles it than the pressure which moves the trigger of a gun resembles the explosion which follows.

Finally, the induction extends itself to the sensations of tension and pressure which we ascribe to mechanical force, ordinarily so-called. The same weight produces one kind of feeling when it rests on a passive portion of the body, and another kind of feeling when supported at the end of the outstretched arm. Or, to take a better case—if, one hand being opened out on the table, a knuckle of the other hand is thrust down with some force on the back of it, there results a sensation of pain in the back of the hand, a sensation of pressure in the knuckle, and a sensation of muscular tension in the active arm. Which of these sensations does the mechanical force in action resemble, qualitatively or quantitatively? Clearly, it cannot be assimilated to one more than another of them; and hence must in itself be something alien from, or unrepresentable by, any feeling.

Thus we are brought to the conclusion that what we are conscious of as properties of matter, even down to its weight and resistance, are but subjective affections produced by objective agencies that are unknown and unknowable. All the sensations produced in us by environing things are but symbols of actions out of ourselves, the natures of which we cannot even conceive.

§ 87. This conclusion fully harmonizes with, and is indeed an obvious corollary from, those truths which Physiology supplies as data to Psychology. Let us briefly note how the structural and functional facts set down in the preceding part, yield deductively the inferences above reached inductively.

A nerve is a thread of unstable nitrogenous substance running from periphery to centre or from centre to periphery, along which, when one of its ends is disturbed, there runs a wave of molecular change to the other. The wave of change set up by a peripheral disturbance is not like the action which causes it; and the waves of change set up in different nerves by different peripheral disturbances have no such unlikenesses as have the disturbances themselves. Hence being obliged to conclude that the kind of feeling depends either on the character of the nerve-centre, or on the way in which the molecular disturbance is brought to the nerve-centre, or on both; it becomes inconceivable that any resemblance exists between the subjective effect and that objective cause which arouses it through the intermediation of changes resembling neither.

Similarly with the quantitative variations. Seeing, as we did, that every nervous disturbance propagated from periphery to centre undergoes a multiplication, the degree of which depends primarily on the particular multiplying structures passed through, and secondarily on the changeable physiological conditions which favour or hinder the multiplication; it is clear that, if what on its physical side is a central nervous disturbance, is on its psychical side a feeling, there cannot be constant proportions between feelings and the environing stimuli to which they answer. Quantitatively as well as qualitatively, feeling must be relative to the nature and state of the subject.

§ 88. But now let us not overlook an all-important implication very generally overlooked, and the overlooking of which leads to elaborate systems of erroneous inferences of very remarkable, not to say astonishing, kinds.

All the foregoing arguments, and all arguments of kindred natures, set out by assuming objective existence. Not a step can be taken towards the truth that our states of consciousness are the only things we can know, without tacitly or avowedly postulating an unknown something beyond consciousness. The proposition that whatever we feel has an existence which is relative to ourselves only, cannot be proved, nay cannot even be intelligibly expressed, without asserting, directly or by implication, an external existence which is not relative to ourselves. When it is argued that what we are conscious of as sound has no objective reality as such, since its antecedent is also the antecedent to what we are conscious of as jar, and that the two consequents, being unlike one another, cannot be respectively like their common antecedent; the validity of the argument depends wholly on the existence of the common antecedent as something that has remained unchanged while consciousness has been changing. If, after finding that the same tepid water may feel warm to one hand and cold to the other, it is inferred that warmth is relative to our own nature and our own state; the inference is valid only supposing the activity to which these different sensations are referred, is an activity out of ourselves which has not been modified by our own activities.

One of two things must be asserted:—Either the antecedents of each feeling, or state of consciousness, exist only as previous feelings or states of consciousness; or else they, or some of them, exist apart from, or independently of, consciousness. If the first is asserted, then the proof that whatever we feel exists relatively to ourselves only, becomes doubly meaningless. To say that a sensation of sound and a sensation of jar cannot be respectively like their common antecedent because they are not like one another, is an empty proposition; since the two feelings of sound and jar never have a common antecedent in consciousness. The combination of feelings that is followed by the feeling of jar, is never the same as the combination of feelings that is followed by the feeling of sound; and hence, not having a common antecedent, it cannot be argued that they are unlike it. Moreover, if by antecedent is meant constant or uniform antecedent (and any other meaning is suicidal) then the proposition that the antecedent of sound exists only in consciousness, is absolutely irreconcilable with the fact that the feeling of sound often abruptly breaks in upon the series of feelings otherwise determined, where no antecedent of the specified kind has occurred. The other alternative, therefore, that the active antecedent of each primary feeling exists independently of consciousness, is the only thinkable one. It is the one implicitly asserted in the very proposition that feelings are relative to our own natures; and it is taken for granted in every step of every argument by which this proposition is proved.

Thus we come once more by another route to the conclusion already twice reached. In the first part of *First Principles*, when treating of the relativity of knowledge, it was shown that the existence of a non-relative is unavoidably asserted in every chain of reasoning by which relativity is proved. In the second part of *First Principles*, when dealing with the Data of Philosophy, it was shown that the co-existence of subject and object is a deliverance of consciousness which, taking precedence of all analytical examination, but subsequently verified by analytic examination, is a truth transcending all others in certainty. And here again, the validity of the conclusion that whatever we feel exists as we feel it only in ourselves, we find to depend entirely upon the postulate that feelings have antecedents out of ourselves.

CHAPTER IV.

THE RELATIVITY OF RELATIONS BETWEEN FEELINGS.

§ 89. The mildest criticism on this title will probably be that it is an awkward combination of words; and an outspoken critic will very likely condemn it either as nonsensical or as meaningless. Nevertheless it has a definite meaning not properly expressible by any other title.

Mind we found to be composed of feelings and the relations between feelings. In the last chapter, it was shown that the kinds and amounts of feelings are determined by the nature of the subject—exist, as we know them, only in consciousness, and have no resemblance to the agents beyond consciousness which cause them. And it is the purpose of this chapter to show that in like manner the forms and degrees of relations between feelings are determined by the nature of the subject—exist, as we know them, only in consciousness, and no more resemble the connexions between outer agents than the feelings they unite resemble these outer agents.

The most highly compounded relations between feelings, are those in which they are present to consciousness not simply as co-existing but as co-existing in certain relative positions—co-existing, that is, along with many of those intervening and surrounding positions which are the units of our conception of Space. The relativity of those compound relations of Co-existence, as we may call them, must be dealt with first. After them we will pass to the compound relations of Sequence, or those in which feelings are known not simply as having occurred in succession, but as occupying certain positions in the series of states of consciousness, between which there are intervening positions occupied by other states—relations of Sequence, that is, in which Time, regarded as having an assignable quantity, is an element. We will next consider the compound relations of Difference, or those in which beyond the mere consciousness of Difference, there is a consciousness of the degree of Difference—relations of Difference, that is, in which the related feelings are conceived as differing in strength by assignable amounts. The relations of Co-existence, of Sequence, and of Difference, considered under their simplest aspects apart from quantitative implications, may then occupy us.

§ 90. No great effort of imagination is required to see that the consciousness of space of three dimensions, constituted of trebly-compounded relations of Co-existence, is a consciousness that varies qualitatively according to the structure of the species. It needs but to call to mind how greatly our conception of space is modified when we are in a dark place of which we know not the bounds, to perceive that those inferior creatures which have no eyes, and cannot, as we do in the dark, supplement present tactual experiences by remembered visual experiences, must have conceptions of space quite unlike in quality to our own, which are abstracted in so large a degree from visual experiences. Not only must the consciousness of trebly-compounded relations of Co-existence be qualitatively different in such inferior creatures, but also those of doubly-compounded and singly-compounded relations of Co-existence. A creature with eyes is capable of having all the relative positions constituting an area, impressed on consciousness with apparent simultaneity; but a creature without eyes can become conscious of these multitudinous relative positions only through continued tactual explorations, presenting most of them in distinct succession. And whereas space of one dimension is knowable by the seeing creature as a seemingly-instantaneous consciousness of the relative positions of two things impressing it, the consciousness of these relative positions in a creature without eyes (unless the things are so close as to be touched at the same instant by two parts of the creature's body) cannot be seemingly instantaneous, but must last during the appreciable period required for muscular movement of a limb, or of the body, from one to the other. Of course such qualitative differences among compound relations of Co-existence as present to consciousness, must have countless gradations, determined by the perfection of sight and the range of sight. It may be added that there is even a species of qualitative variation that occurs in the same creature using the same senses. Take two objects sufficiently far apart to give standing room between them. Having contemplated their relation of position from a distance, contemplate it afresh after having so placed the body that one of them is in front and one of them is behind. It will be found that what is conceived as a single relation in the one case cannot be so conceived in the other. While standing between the two objects, it is possible to think of their relative positions only by thinking successively of their two relations of position with self. That compound relations of Co-existence as conceived by different species, vary quantitatively with the structures of the species, seems, to say the least, very probable. Animals having great locomotive powers are not likely to have the same conceptions of given spaces as animals whose locomotive powers are very small. To a creature so constructed that its experiences of the larger spaces around have been gained by long and quick bounds, distances can scarcely present the aspects they do to a creature which traverses them by slow and many steps.

The dimensions of our bodies and the spaces moved through by our limbs, serve us as standards of comparison with environing dimensions; and conceptions of smallness or largeness result according as these environing dimensions are much less or much greater than the organic dimensions. Hence, the consciousness of a given relation of two positions in space, must vary quantitatively with variation of bodily bulk. Clearly, a mouse, which has to run many times its own length to traverse the space which a man traverses at a stride, cannot have the same conception of this space as a man. Quantitative changes in these compound relations of Co-existence are traceable by each person in his own mental history, from childhood to maturity. Distances which seemed great to the boy seem moderate to the man; and buildings once thought imposing in height and mass, dwindle into insignificance.

The physiological state of the organism also modifies quantitatively this form of consciousness to a considerable extent. De Quincey, describing some of his opium-dreams, says that " buildings and landscapes were exhibited in proportions so vast as the bodily eye is not fitted to receive. *Space swelled*, and was amplified to an extent of unutterable infinity." It is not an uncommon thing with nervous subjects to have illusive perceptions in which the body seems enormously extended: even to the covering an acre of ground.

A more special modification of bodily state also affects the conception. Like all other nervous structures, the nervous structures employed in the apprehension of space have their receptivity temporarily diminished by action. As the appreciation of a delicate taste is hindered when the palate has just been excited by a very strong taste; so a small or moderate magnitude is under-estimated when a great magnitude has just before occupied the attention. A building that appeared large when it stood amid smaller buildings, loses much of its seeming largeness if a far larger building is erected close to it. Or, to take a better case—when the Sun is seen in the midst of the sky, with none but great angular spaces between it and the horizon, it looks very much less than it does when close to the horizon, where the angular space it subtends is comparable side by side with small angular spaces.

Yet again, compound relations of Co-existence vary with the position of the observer, not only quantitatively, but, in a certain sense, qualitatively; for so only can we express the truths that apparent size depends on distance from the eye, and that apparent form changes with every change in the point of view. The impressions made on us by two objects to both of which we are close, are considerably removed from one another in consciousness. But as we recede from such two objects, that compound relation of Co-existence which forms our conception of their relative positions, diminishes quantitatively, and at last disappears altogether: the two impressions they give us merge into one. The facts that the co-existent positions forming a circle become to perception an ellipse when viewed obliquely, and a straight line when viewed edgeways, illustrate the truth that compound relations of Co-existence undergo a species of qualitative variation as the place of the percipient varies. This kind of variation is doubtless due to differences among the rates of quantitative variation of the many component relations; but it is none the less to be regarded as a qualitative variation, since differences of quality in general are resolvable into differences in the ratios of the co-operative factors.

We are thus driven to the conclusion that what we conceive as space-relations, cannot be, either in their natures or degrees, like those connexions among external things to which they are due. They change both qualitatively and quantitatively with the structure, the size, the state, and the position, of the percipient. And when we see that what is, objectively considered, the same connexion between things, may, as a space-relation in consciousness, be single or double—when we remember that, according as we are near or far off, it may be too large to be simultaneously perceived or too small to be perceived at all; it becomes impossible to suppose any identity between this objective connexion and some one of the multitudinous subjective relations answering to it.

§ 91. The compound relations of Sequence, or those in which we conceive phenomena as having occurred, not simply one after another, but as occupying places in consciousness between which there are intervals measured by intervening places, and from which, by abstraction, we derive our conception of Time, do not at first sight appear to vary qualitatively. Reasons may, however, be assigned for suspecting qualitative variations in them.

Such qualitative variations as probably occur, are determined by differences of specific structure. A stationary creature without eyes, receiving distinct sensations from external objects only by contacts which happen at long and irregular intervals, cannot have in its consciousness any compound relations of sequence save those arising from the slow rhythm of its functions. Even in ourselves the respiratory intervals, joined sometimes with the intervals between the heart's pulses, furnish part of the materials from which our consciousness of duration is derived; and had we no continuous perceptions of external changes, and consequently no ideas of them, these rhythmical organic actions would obviously yield important data for our consciousness of Time: indeed, in the absence of locomotive rhythms, our sole data. Remembering this, and remembering that the sequences with which we are chiefly occupied, and from which our conception of Time is chiefly abstracted, are not these sequences derived from internal actions, but the sequences in our impressions of external actions, it will be manifest that there is most likely a marked qualitative difference between that undeveloped sense of duration derived solely from the experiences of inner changes, and that developed conception of Time derived mainly from outer changes, but conceived to be a form of both outer and inner changes. Quantitative variations in compound relations of Sequence as existing in consciousness, are manifestly caused by the structural differences which constitute differences of species. Subjective rhythms, partly of the vital functions and partly of the locomotive functions, mark out consciousness into tolerably regular intervals; thus yielding measures between states of consciousness otherwise caused—standards of duration. Hence a small creature, in which these rhythms are very rapid, must have a consciousness of a given objective interval widely unlike the consciousness of it possessed by a large animal, whose rhythms are relatively very slow. A gnat's wings make ten or fifteen thousand strokes per second. Each stroke implies a separate nervous action. Each such nervous action, or change in a nervous centre, is probably as appreciable by the gnat as is a quick movement of his arm by a man. And if this, or anything like this, is the fact, then the time occupied by a given external change, measured by many movements in the one case, must seem much longer than it seems in the other case, when measured by a single movement.

How age determines quantitative variations in compound relations of Sequence, is a matter of common remark. Probably these are in part due to differences of size, and concomitant differences in the rhythms of the functions, vital and locomotive: it requires a greater number of a child's movements than of a man's movements to measure a day. But that the change in the estimation of intervals is not wholly thus caused, is manifest from the fact that after maturity is reached, they, or at any rate the longer ones, continue to undergo a seeming abbreviation. Months to the old man appear no longer than weeks to the young man.

A further quantitative variation, essentially similar in origin to that which takes place with advancing years, accompanies variation in external circumstances, when this increases or decreases the number of vivid experiences within a given interval. If, after a monotonous life, a journey of pleasure brings within a week many exciting novelties, the remark habitually made is, that it seems far more than a week since home scenes were left behind. Even a comparatively monotonous state of consciousness appears long if it is intense: instance the time during which a severe pain is suffered; or instance an interval of impatient expectation, the seeming length of which is popularly illustrated by the proverb—"The watched pot never boils."

The estimation of Time varies also with the constitutional state. Whatever exalts the vital activities, and so makes mental impressions stronger, exaggerates the conceptions of durations. This is notably the case in persons under the influence of opium. Detailing his experiences of this influence, De Quincey says that he sometimes seemed "to have lived for 70 or 100 years in one night;" nay, to have had "feelings representative of a millennium passed in that time, or, however, of a duration far beyond the limits of any human experience."

One more cause of quantitative variation in the consciousness of a compound relation of Sequence, is change of position among our experiences. Intervals of Time, like intervals of Space, become apparently small in proportion to their remoteness. An evening spent at a friend's house, seems of considerable length when looked back upon at the moment of departure. When recalled a week after, it subtends by no means so great an angle in consciousness; and the angle it subtends in consciousness when we are reminded of it a year after, is very small. There is a conviction that it was several hours long; but when contemplated it cannot be made of equal apparent length with the several hours just passed, any more than the apparently-small distance between two objects on the horizon, can be made in actual perception like the great interval which appeared between them when we saw them close at hand. In other words, there is a fore-shortening of protensive quantity analogous to the fore-shortening of extensive quantity; whence it results that the intervals between passing experiences begin to seem less as soon as they are past, and continually dwindle as we get further from them, until at last their lengths become inappreciable. To this law of mental perspective is due the fact that, in retrospect, life seems no longer at forty than it did at twenty.

Hence, concerning compound relations of Sequence, as concerning compound relations of Co-existence, we must say that probably they are not qualitatively like the connexions to which they answer, and certainly they are not quantitatively like them. For suspecting that whatever objectively originates our subjective conception of Time, is not identical in nature with it, we have the reason that Time, considered as an abstract from relations of Sequence, must present a different aspect according to the degree of its dissociation from particular sequences. To a lowly-endowed creature, conscious only of internally-initiated changes, it cannot appear what it does to a creature chiefly occupied with changes that are externally initiated; since, in the last, it is partially dissociated from both orders of changes. Whence it seems inferable that, only partially dissociated as it is, it cannot have in consciousness that qualitative character which absolute dissociation would give it, and which we must suppose it to have objectively. And that compound relations of Sequence as we conceive them, cannot be quantitatively like the connexions beyond consciousness to which they refer, is proved by the fact that they vary in their apparent lengths with the structure of the organism, with its size, with its age, with its constitutional state, with the number and vividness of the impressions it receives, and with their relative positions in consciousness.

Manifestly, as no one of these variously-estimated lengths can be taken as valid rather than the others, it becomes impossible to suppose equality between an interval of time as present to consciousness and any nexus of things which it symbolizes.

§ 92. Deeper than the compound relations of Co-existence and Sequence, is the compound relation of Difference; since, besides being involved in the comparisons of spaces and of times, this is involved in comparisons of the Forces manifested in Space and Time. We may fitly limit ourselves to illustrations taken from this last class of cases.

As into a conception of two things co-existing at an assignable distance apart, there enters the consciousness of many or few co-existing positions between them; and as into the conception of two changes separated by an assignable interval of time, there enters the consciousness of many or few intervening sequent positions; so into the conception of two forces that have an assignable inequality, there enters the consciousness of many or few degrees of difference; and the conceived amount of difference is determined by the number of these degrees. What we have here to observe is, that our conceptions of amounts of difference, so constituted, have relativities analogous to those which exist in our conceptions of amounts of spaces and amounts of times.

That the compound relation of Difference varies qualitatively according to the structure of the species, we have no distinct evidence. But since a compound relation of Difference has to be conceived in terms of impressions that differ; and since the conception of Difference cannot be dissociated from the order of impressions in which it is presented, if there is but one such order; it may be inferred that, in proportion as the impressions become more multitudinous in their kinds, the conception of Difference becomes more independent of particular differences; and that, therefore, in higher creatures it is not qualitatively the same as in lower creatures.

That quantitative variations in the conception accompany specific unlikenesses of structure, becomes manifest when it is remembered that a difference in forces does or does not give rise to a difference in feelings, according as the organization is or is not highly recipient. Incident forces that seem alike to a lowly-endowed creature, seem conspicuously unlike to a creature endowed with the sense-organs required for appreciating them. Where eyes are so little developed that approaching objects are recognized only as intercepting the sunshine, it is obvious that contrasts of light and shade which seem marked to animals with developed eyes, are quite imperceptible. Similarly among highly-endowed animals of diverse kinds. Between odours both of which produce in a man no impression whatever, a dog perceives differences of strength, probably of many degrees. Even the structural unlikenesses of individuals entail such results. A good ear detects several gradations between tones which to a bad ear seem alike.

The bulk of the organism is also a factor in modifying quantitatively the relation of Difference. The manifestations of force between which a creature can perceive unlikenesses, are limited at the one extreme by its ability to bear them and at the other extreme by its capacity for being sensibly affected by them; and its size partly determines these limits. A grain and half-a-grain are hardly distinguishable by their pressures on the finger; but if successively borne by an animal not more than a grain in weight, a difference divisible into many degrees would doubtless be perceptible between them. Conversely, a man cannot perceive the contrast in weight between a ton and half-a-ton, for he fails to put forth a force sufficient to lift either; but it can scarcely be questioned that in the consciousness of an elephant, now loaded with one and now with the other, the feelings produced would have an unlikeness that might be graduated. Objective differences, all equal in degree, are thus manifestly appreciable by any creature only within a range that is really very narrow. Moreover, it is demonstrable that towards either extremity of this range, the conceptions of Difference become quantitatively more and more vague; and nowhere throughout the range can there be maintained a parallelism between the contrasts of inner feelings and the contrasts of outer forces to which they refer. For when a mass is poised in the hand, certain muscles are strained to the degree required to support the mass *plus* the arm. If the weight of the mass is small, the weight of the arm becomes the larger part of the force to be antagonized; while if the mass is large, the weight of the arm becomes the smaller part. Clearly, then, the effort put forth for the support of the arm being a constant element in the compared states of consciousness, must modify the seeming difference between weights to a different extent according as the absolute amounts of the weights are increased or decreased.

How variations of constitutional state, whether determined by disorder or by age, also cause quantitative variations in the relations of Difference as conceived by us, need not be shown in detail. It is obvious from what has been said that all exaltations and depressions of energy and of sensibility, must alter the range within which differences are appreciable, and must modify the appreciations of them: more especially towards each extreme of the range.

We conclude, then, that the compound relation of Difference as we know it, is dependent on structure, on size, and on constitutional state. The same objective difference may have no subjective difference answering to it, because the forces between which it exists are either excessive or defective in amount. Within the limits of appreciation, the same objective difference may seem great or small according to the percipient's nature and temporary condition. And as we cannot fix on any one of these relations in consciousness, rather than any other, as like the reality beyond consciousness, we must infer that there is no likeness between any one of them and the reality beyond consciousness.

§ 93. But now what are we to say about the pure relations of Co-existence, of Sequence, and of Difference; considered apart from amounts of Space, of Time, and of Contrast? Can we say that the relation of Co-existence, conceived simply as implying two terms that exist at the same time, but are not specified in their relative positions, has anything answering to it beyond consciousness? Can we say that out of ourselves there is such a thing as Succession, corresponding to the conception we have of one thing coming after another, without reference to the time between them? And can we say that what we know as Difference, apart from any particular degree of it, has objective unlikeness as its cause?

The reply is that we cannot frame ideas of Co-existence, of Sequence, and of Difference, without there entering into them ideas of quantity. Though we have examined apart the compound relations of these orders, into which consciousness of quantity avowedly enters; and though, in above defining the simple relations of these orders, the avowed contemplation of quantity is excluded; yet, on looking closely into the matter, we find that a tacit recognition of quantity is always present. Co-existence cannot be thought of without some amount of space. Sequence cannot be thought of without some interval of time. Difference cannot be thought of without some degree of contrast. Hence what has been said above respecting these relations in their definitely-compound forms, applies to them under those forms which, by a fiction, we regard as simple. All the proofs of relativity that held where the conceived quantities were large, hold however small the conceived quantities become. And as the conceived quantities cannot disappear from consciousness without the relations themselves disappearing, it follows inevitably that the relativities hold of the relations themselves in their ultimate elements. We are thus forced to the conclusion that the relations of Co-existence, of Sequence, and of Difference, as we know them, do not obtain beyond consciousness.

Let us simplify the matter by reducing derivative relations to the fundamental relation; and we shall then see more clearly the truth of this apparently-incredible proposition.

Every particular relation of Co-existence involves a cognition of some difference in the positions of the things co-existing; resolvable, ultimately, into differences of relative position towards self. And differences of relative position can be known only through differences between the states of consciousness accompanying the disclosure of the positions. But while positions in Space, and co-existing objects occupying them, are known through relations of Difference between the feelings accompanying disclosure of them; they are known through relations of Likeness, in respect of their order of presentation. The relation of Co-existence, which is that out of which all Space-conceptions are built, is one in which neither term is first or last; the terms exhibit equality in their order—no difference in their order.

Phenomena occurring in succession, like those occurring simultaneously, are known as occupying different positions in consciousness. Intervals between them are distinguished by differences in the feelings that arise in passing over the intervals; and where the intervals are alike, they are so classed from the absence of such differences. But while the relations among phenomena in Time are known as such or such through conceptions of Difference and No-difference yielded by comparisons of them, they are known as alike in this, that their terms are unequal in order of presentation—differ in their order.

Thus all Space-relations and Time-relations—all relations of Co-existence and Sequence, are known through relations of Difference and No-difference. Sequence is Difference of order; Co-existence is No-difference of order. Hence we have at last to deal with the relations of Difference and No-difference. And our entire consciousness being built up of feelings which present these relations, both in themselves and in the secondary feelings constituting consciousness of their order, the whole question of the relativity of relations among feelings is reducible to the question of the relativity of the relation of Difference. This is readily demonstrable.

The sole elements, and the indissoluble elements, of the relation are these:—A feeling of some kind; a feeling coming next to it, which, being distinguishable as another feeling, proves itself to be not homogeneous with the first; a feeling of shock, more or less decided, accompanying the transition. This shock, which arises from the difference of the two feelings, becomes the measure of that difference—constitutes by its occurrence the consciousness of a relation of difference, and by its degree the consciousness of the amount of difference. That is, the relation of Difference as present in consciousness is nothing more than a change in consciousness. How, then, can it resemble, or be in any way akin to, its source beyond consciousness? Here are two colours which we call unlike. As they exist objectively, the two colours are quite independent—there is nothing between them answering to the change which results in us from contemplating first one and then the other. Apart from our consciousness they are not linked as are the two feelings they produce in us. Their relation as we think it, being nothing else than a change of our state, cannot possibly be parallel to anything between them, when they have both remained unchanged.

§ 94. It is proper to point out that all these conclusions, down to the last of them, are in harmony with those which may be directly deduced from the data supplied by Physiology to Psychology.

Each feeling being the concomitant of some molecular change in a portion of vesicular nerve-matter; and each relation being the concomitant of some wave of molecular transformation propagated along a nerve-fibre, or fibres, from one portion of vesicular nerve-matter to another; it results, in the first place, that the various relations as we know them are composed of elements essentially alike; and it results, in the second place, that not being intrinsically different in their ultimate natures, they cannot resemble intrinsically-different objective connexions.

Indeed, it needs but to think for an instant of a brain as a seat of nervous discharges, intermediate between actions in the outer world and actions in the world of thought, to be impressed with the absurdity of supposing that the connexions among outer actions, after being transferred through the medium of nervous discharges, can re-appear in the world of thought in the forms they originally had.

§ 95. But here let us not omit to recognize the assumption made throughout, and inevitably made in all reasoning used to prove the relativity of relations, that there exist beyond consciousness, conditions of objective manifestation which are symbolized by relations as we conceive them.

The very proposition that what we know as a relation is qualitatively and quantitatively determined by our own nature, and does not resemble any order or nexus beyond consciousness, implies that there exists some such order or nexus beyond consciousness; and every step in every argument by which this proposition is established, distinctly posits this order or nexus, and cannot be taken on any other condition. Further, the argument assumes, and is obliged to assume, fundamental differences of objective order which are symbolized by fundamental differences of subjective order.

For to say that what we know as a relation between positions in Space, cannot be like any objective nexus, since this relation of positions as conceived by us varies indefinitely, is to say that there exists an objective nexus which has not varied. Two verdicts of consciousness respecting a given magnitude are found to be unlike under unlike conditions of perception; whence it is inferred that neither of them is like the magnitude. But the inference is nonsense if by this magnitude is meant something in consciousness, instead of something beyond consciousness. As it was before shown in the case of feelings, so it might here be shown in the case of relations between feelings, the reasoning used becomes both false in its premises and meaningless in its conclusion. Of course, changing the terms, the like holds with periods of Time. Every argument proving that our conceptions of Time are relative, falls to pieces on withdrawing the assumption that there exists some form of Things from which Time, as a form of Thought, is derived.

The assumption of an objective source for the subjective relation of Difference, is implied in the last two assumptions. If, as shown above, all special cognitions of spaces and times involve cognitions of differences; and if, as shown above, Space in general, which is resolvable into relations of Co-existence, and Time in general, which is resolvable into relations of Sequence, are separable from one another as being respectively constituted, the last by difference of order, and the first by no-difference of order; it is clear that the postulation of objective sources of these subjective forms, implies postulation of an objective source of Difference. And this postulation of an objective source of Difference, equally implied in all the arguments which prove the relativity of the conception of Difference, has for its ultimate warrant the deepest assignable warrant—the Persistence of Force. Though the relation of Difference, constituted, as we have seen, by a change in consciousness, cannot be identified with anything beyond consciousness; yet that there is something beyond consciousness to which it is due, is an inevitable conclusion; since to think otherwise is to think of change taking place without an antecedent.

More certain, then, than the Relativity of Relations as we conceive them, is the existence of Non-relative Forms to which they refer; since proof of the first involves perpetual assumption of the last. There is some ontological order whence arises the phenomenal order we know as Space; there is some ontological order whence arises the phenomenal order we know as Time; and there is some ontological nexus whence arises the phenomenal relation we know as Difference.

CHAPTER V.

THE REVIVABILITY OF FEELINGS.

§ 96. As was pointed out in the second chapter of this part, Feelings admit of a double classification. On grounds of structure they are divisible into the centrally-initiated and the peripherally-initiated; which last are re-divisible into those which are peripherally initiated by external actions and those which are peripherally initiated by internal actions. And on grounds of function they are divisible by a line crossing these transversely, into those primary or vivid feelings produced by direct excitations, and those secondary or faint feelings produced by indirect excitations. The one class, known as sensations, are sometimes called presentative feelings; and the other class, known as ideas (though this word is more commonly applied to clusters of them), are sometimes called re-presentative feelings.

Thus far little regard has been paid to this grouping of feelings which has in view not difference of kind but difference of degree. Though throughout the last two chapters, we have tacitly recognized the distinction—though, in dealing with the relativities of feelings and of relations, we have been obliged to take for granted an established connexion between the vivid feelings or sensations directly presented and the faint feelings or ideas in which they are represented, yet no definite statements have been made respecting the dependence of the second class on the first. Here we have to inquire how, when vivid forms of feelings have been experienced, it happens that faint forms of feelings like them afterwards arise. We have to inquire what determines this revivability—what conditions they are which render the revivals more or less distinct.*

Since feelings are rarely, or indeed never, revived singly—since the things we remember are, as the word implies, put together out of feelings standing in certain relations; it results that in the illustrations to be given we shall have to deal more with clusters of revived feelings than with individual revived feelings. But what is alleged of the first always holds of the last.

§ 97. Speaking generally, feelings are revivable in proportion as they are relational. The peripherally-initiated feelings of external origin are more representable than those of internal origin; and both of these can be represented with greater facility than the centrally-initiated feelings.

The most highly relational feelings are the visual; and these are of all feelings the most easily reproduced in thought. The redness of a soldier's coat, the blue of the sky, the whiteness of the snow-covered ground, can be revived in consciousness at any moment with scarcely an effort, and with relatively-great clearness. The glare of an electric light may be so vividly conceived as to produce something like a sense of dazzling. Ideal feelings of sound arise before the mind with a facility and a strength almost as great. The report of a cannon, the

* I here use the word revivability rather than the word recoverability, because it has less objectionable implications. To recover anything involves a voluntary act; and to call a thing recoverable, is to say that it is something which can be re-obtained by a voluntary act. But a great part of our ideal feelings arise without volition, and often in spite of volition. The word revivable applies equally well to the ideal feelings which are voluntary and those which are involuntary.

blast of a trumpet, a groan, or a hiss, may be imagined instantly and very distinctly. Sensations of touch and pressure, if less representable, are representable readily and with considerable clearness. The softness and hardness, the smoothness and roughness, of different surfaces, have tolerably distinct ideal forms that recur with facility. The less relational feelings externally initiated—those of taste and smell—are neither so easily nor so strongly reproduced. A colour or sound may be remembered in an instant; but a specified flavour or odour is not so quickly recalled, and the ideal feeling does not approach in vividness so nearly to the real feeling.

We pass to the peripherally-initiated feelings of internal origin. A particular muscular effort cannot be represented as quickly or as clearly as a particular sound or colour; and though an intense pain suffered in a limb may be recalled with considerable distinctness, it is observable that the ideal pain does not approach so nearly to the real pain as does a remembered scream to the consciousness of an actual scream, or as does the thought of a flash of lightning to the perception of a flash of lightning. When we come to those peripherally-initiated feelings to which ordinarily states of the viscera give rise, we find the degree of revivability very small. It is difficult to call into consciousness the feeling of hunger. To think of the circumstances along with which hunger occurs is easy; but after a hearty meal it is next to impossible to represent any degree of that craving for food which existed before the meal. Similarly with thirst.

Of the centrally-initiated feelings or emotions, the like is true in a qualified sense. As before pointed out, there is not between actual and ideal emotions the same sharp division as between actual and ideal feelings of other kinds. Emotions are excited, not by physical agencies themselves but by certain complex relations among them. Hence, only by representations of such complex relations are ideal emotions aroused. When so aroused, however, they may rise to any degree of vividness, until they become actual emotions. But the fact which we have here to note as conforming to the principle enunciated, is that an emotion cannot be at once revived in the same way that a feeling of light or sound can. It is impossible to bring instantly into consciousness the passion of anger, or that of joy, in however faint a form. Representation of either can be achieved only by imagining, and dwelling upon, some circumstances calculated to produce it; and this takes an appreciable time.

§ 98. The revivability of past feelings varies inversely as the vividness of present feelings. This antagonism holds to a certain degree between past and present feelings in general; but it holds to a much greater degree between past and present feelings belonging to the same order.

Take first the general antagonism. Every one knows that when a tremendous sound or an astounding spectacle absorbs the attention, it is next to impossible to think of anything else—next to impossible to entertain irrelevant ideas. Indeed, consciousness sometimes becomes so entirely filled with the present overpowering impressions as to extrude our habitual ideas: producing what we call absence of mind. Less extreme illustrations are furnished by the interruptions to currents of voluntary thought that result from violent pains or loud noises. And that the shutting out of primary feelings facilitates the revival of secondary feelings, is also implied by the common habit of closing the eyes when trying to imagine anything very clearly.

The more special antagonisms are of considerable interest. We saw in a previous chapter that primary feelings of any order, while they have much power of excluding from consciousness primary feelings of the same order, have less power of excluding from consciousness primary feelings of other orders. Here we have to note, what may be regarded as a corollary, that primary feelings of any order are greater obstacles to secondary feelings of that order than they are to secondary feelings of other orders. Visual impressions of great distinctness offer a scarcely-appreciable resistance to the imagination of sounds—say those forming a melody. The revival in thought of a person recognized yesterday, is but little interfered with by the flavours of the things we are eating. Nor do the sensations received from objects held in the hands, hinder us much from thinking of things we have seen, or listened to, or tasted, or smelt. But the sounds we are hearing tend very decidedly to keep out of consciousness other sounds of which we wish to think. Visual sensations stand considerably in the way of visual ideas. And there are still more conspicuous antagonisms between the primary feelings and the secondary feelings of lower orders.

The different degrees of these antagonisms are, indeed, worthy of notice; since they admit of being generalized, and are not without significance. The law appears to be that among the most relational feelings, the primary of any order resist the secondary of the same order to the least extent; and that the resistance becomes more decided in proportion as we descend to feelings that are less and less relational. Beginning with the most relational feelings, it is observable that only by a very intense visual sensation are the ideas of other visual sensations entirely excluded. Thus it is impossible while staring at the Sun to think of green; but it is quite possible, or even easy, while looking at a surface coloured red, to think of a patch of green covering part of its area; and we can, with considerable distinctness, imagine the clustered colours forming the remembrance of any object, while the retina is receiving the clustered colours yielded by actual objects quite different from it. Of auditory impressions the like may be said. Loud sounds prevent us from bringing the ideas of other sounds into consciousness;

but they must be extremely loud to do this. And when listening to an orchestra, it will be found that while, during the *forte* passages, it is difficult to imagine some other musical combination than that which is being heard, it is comparatively easy during the *piano* passages. Much the same holds among feelings of touch. The sensations yielded by an object held loosely, do not prevent us from remembering the sensations yielded by other quite different objects; and it is needful to grasp an actual object very strongly, so that the sensations of touch, or rather of pressure, verge into those of pain, before remembered tactual feelings are quite extruded. When we come to such comparatively-unrelational feelings as the gustatory and olfactory, we find this antagonism far more marked. While tasting something decidedly bitter, sweetness cannot be thought of: indeed, tastes of even moderate intensity almost prevent us from imagining other tastes. And this antagonism reaches its extreme among the visceral feelings, where, indeed, it appears to be absolute.

§ 99. Other things being equal, the revivability of a feeling varies with its strength; and other things being equal, its revivability varies with the number of times it has been repeated in experience. The triteness of these truths must not prevent us from here briefly noticing them.

The glow of a gorgeous sunset continues to be recallable long after faintly coloured scenes of the same date have been forgotten. The sound of a trumpet may be more quickly and clearly imagined than that of a bassoon. It is easier to remember the taste of something that is intensely sour or sweet or bitter than the taste of something that is almost insipid. And a very severe pain leaves a trace in memory which lasts long after the traces left by slight aches and discomforts have disappeared.

How repetitions even of faint feelings produce great revivability of them, we see on comparing our domestic experiences with less common experiences. The colour of the paper in a frequented room, subdued though it is, can be very distinctly recalled. The tone of a voice which is heard daily, may be thought of much more easily and truly than the tone of a voice, not more marked in character, that has been heard but once or twice.

But the other things which we have supposed to be equal, are usually not equal. Besides the psychological state which, as we have seen, influences the revivability, there is the physiological state, which also influences it in several ways. These we must now consider.

§ 100. The degree of revivability of a feeling depends in part on the extent to which the nervous centre concerned was capable of undergoing much molecular change, and evolving much of the concomitant feeling, when the original excitation was received. Several factors co-operate to determine its capability. A complete state of repair is one of them. An active circulation is another. A blood rich in the materials required for both disintegration and integration is a third. The respective shares of these factors cannot be determined; for the three usually vary together. But the influences of two, at least, may be pretty clearly identified.

When the attention has been long occupied with any class of impressions—when, that is to say, the nervous centres concerned have been worn by persistent action, the impressions received cannot be recalled as clearly as those received when these nervous centres were unworn. Excluding cases in which abnormal excitement of the local circulation has been produced (cases to be dealt with under the next head), it is a familiar fact that after many hours spent in listening to music, or in looking at pictures, the clustered sensations, auditory or visual, are either not revivable at all, or are less distinctly revivable than those which came first in the concert or the picture gallery. If we take longer periods of continued activity, broken though they are by short periods of rest, a like fact meets us. The experience of every tourist supplies an instance. His first grand mountain-views he can call to mind more clearly than the equally-grand views he had after being among the mountains for a month.

That feelings excited when the general circulation is very vigorous are more revivable than usual, is a truth that may be variously exemplified. Evidence is furnished by both temporary and permanent exaltations of the circulation. Impressions of trivial things in which no particular interest was taken, often survive in memory when impressions of much more important or imposing things fade away; and, on considering the circumstances, it will frequently be found that such impressions were received when the energies were high—when exercise, or pleasure, or both, had greatly raised the action of the heart. That at times when strong emotion has excited the circulation to an exceptional degree, the clustered sensations yielded by surrounding objects are revivable with great clearness, often throughout life, is a fact noticed by writers of fiction as a trait of human nature. As with these quicker variations of vascular activity, so with the slower variations. The receptivity of impressions is high during those portions of life in which the blood is propelled in full and rapid currents. Feelings, peripheral or central, experienced in youth, are long remembered; and while the vigour of manhood continues, the sensations and emotions leave lasting traces.

Equally, or more, obvious is the converse truth, that the revivability of feelings excited during a state of feebleness is comparatively small. The effects of depressed circulation, whether produced by disorder or by age, alike show this. The lowered action of the heart which accompanies great nervous prostration, has for one of its effects a marked decrease of receptivity. Things seen and said and heard are forgotten very quickly—often in a few days. Even the lowered vital activity which we know as great fatigue, is characterized by a diminished retentiveness of impressions. When we pass to that flagging of the circulation which accompanies the decline of life, abundant evidence meets us. Gradually as the vigour decreases there comes an increasing failure of memory. The experiences of a month ago, or of last week, or of yesterday, are not revivable; and in the closing stages of decay things that were looked at and sounds that were heard but a few minutes ago, are found to have left no traces.

There is reason to think that, independently of the general circulation, exaltations and depressions of the cerebral circulation, whether normally or abnormally produced, also affect the degree of revivability of the feelings experienced.

§101. All the circumstances under which an excitation originally occurred being supposed the same, the degree of revivability of the feeling that was produced, varies with the physiological conditions that exist when the revival takes place or is attempted. Other things equal, a given past feeling may be brought into consciousness vividly, faintly, or not at all, according as the nervous centre concerned is or is not well repaired and well supplied with blood at the moment the remembrance is suggested. The evidence assignable in proof of this proposition is mostly entangled with that assigned in proof of the last; but a sufficiency of it may be disentangled.

In that state of high spirits which results from good nutrition and raised circulation, it is observable that the memories are more distinct than usual. Ideas rise up in abundance without effort. Similarly, the vascular excitement caused by emotion, providing it does not reach that extreme pitch at which it prostrates the heart, causes a rush of unusually vivid ideas—ideas so vivid that they are sometimes, as under great fear, mistaken for realities.

How decreased revivability of feelings originally strong, goes along with enfeebled circulation, is exemplified in those exhausted by long illnesses. Highly nervous subjects, too, in whom the action of the heart is greatly lowered, habitually complain of loss of memory and inability to think—symptoms which diminish as fast as the natural rate of circulation is regained. It is, however, in old age that the relation between failure of circulation and decreased revivability of feelings which were efficiently impressed, is most familiar. The power to recall experiences received during adult and declining life, when the vital energies were flagging, is the first to disappear; and presently experiences received during early life, when the vital energies were high, cease to be distinctly revivable.

It may be well to add that variations of local circulation, as well as of general circulation, affect the ability to revive feelings. The illusions of delirium exemplify the extreme vividness to which revived feelings may rise when the cerebral circulation is excessive; and the loss of consciousness caused by cerebral anæmia exemplifies the converse result.

§ 102. Of course quality as well as quantity of blood is a factor, modifying alike the strength with which an impression is retained and the facility with which it can be recalled. The influence of this factor has doubtless a share in producing some of the effects above ascribed to variations of circulation; for quality of blood generally rises and falls along with the vigour of its propulsion. Abnormal deviations, however, show us that quality has its separate effects.

When the circulation has been artificially exalted by stimulants, there is an easy and rapid current of thoughts, showing itself in what we describe as unusual brilliancy. And when the exaltation is produced by certain drugs, as opium and hashish, the revived impressions of things seen and heard, approach in vividness to the original impressions.

We have another class of examples in insane people.

That in them there has arisen some abnormal quality of blood, is now a generally-received opinion; and to this abnormal quality is ascribed that undue vividness of the representative feelings which causes a confusion of them with presentative feelings.

These extreme cases warrant us in supposing that there are minor variations in the revivability of feelings, accompanying those minor variations in the quality of the blood which are caused by differences in the activities of the viscera and differences in the supplies of food and oxygen.

§ 103. The correspondence of these several *à posteriori* conclusions with the *à priori* conclusions derivable from the data of Psychology, must be noticed.

The fact that feelings of any order tend to exclude ideas of the same order more than they do ideas of other orders, is to be expected if particular bundles of nerve-fibres and groups of nerve-vesicles are the agents of particular orders of feelings; for, manifestly, when the structures concerned are undergoing those molecular changes which have vivid feelings for their correlatives, other molecular changes, which have faint feeling for their correlatives, must be greatly obscured. Moreover, we may see why this exclusion is more stringent among the unrelational orders of feelings than among the relational orders of feelings; since, in proportion as an order of feelings is relational, it must have a complex nervous centre, and in proportion as a nervous centre becomes complex, it becomes easy for one part of it to be occupied in one way while another part of it is occupied in another way.

That strong environing actions generate feelings which are more distinctly revivable than those generated by weak environing actions, is also a fact inferable from physiological premises. For as strong environing actions produce strong nervous discharges and great amounts of those central molecular changes of which feelings are the correlatives, it is obvious that they must produce in high degrees those structural changes, whatever they may be, to which the revivability of the feelings is due.

Similarly, it follows that those exaltations of vital activity which facilitate such structural changes, and aid the rapid nutrition which perpetually prepares the parts for them, must conduce to the revivability of the feelings experienced; while depression of the energies must do the reverse.

CHAPTER VI.

THE REVIVABILITY OF RELATIONS BETWEEN FEELNGS.

§ 104. Much that was said in the last chapter in illustration of the propositions it sets forth, serves to illustrate the parallel propositions to be set forth in this chapter. Mind being composed of feelings and relations between feelings, and every mental act involving both kinds of components, it happens that, in exemplifying the revivability of feelings as modified by various conditions, there has been exemplified also the revivability of relations between feelings.

Nevertheless, there remain to be enunciated truths which in the last chapter were but tacitly implied, and other truths that were not even remotely indicated. For though revival of a feeling involves revival of the relations in which it was originally experienced; and though revival of a cluster of feelings, constituting an ordinary idea, involves revival of a whole plexus of relations in which the feelings stood to one another; there is not involved in the recognition of these facts, the further fact that relations may be in great measure parted from the related feelings and revived by themselves. Since quite different pairs of impressions may stand to one another in the same relation of co-existence; and since a sequence may hold together impressions now of this order and now of that; and since differences the same in degree may be presented here by impressions of one species and here by impressions of another; it results that relations of

Co-existence, of Sequence, and of Difference, come to be separable from particular pairs of impressions, and acquire a *quasi*-independence. Their independence never becomes complete; for a relation cannot be conceived without two related terms. But being common to terms of all orders, they come to be conceived apart from terms of any particular order—can have their terms changed in consciousness without being themselves changed; and thus gain a kind of revivability so far independent of any particular terms, as to have an illusive appearance of being independent of all terms.

What we have here to do, then, is to consider the revivability of relations as dissociated little or much from related feelings. Though the several forms of thought under which our feelings are presented and re-presented cannot exist without some contents, yet their contents may be in great part extruded; and we have to observe how these comparatively empty forms comport themselves in respect of their revivabilities, as influenced by psychological and physiological conditions.

§ 105. Relations in general are more revivable than feelings in general. Whether it be a compound relation of Co-existence, or a compound relation of Sequence, or a compound relation of Difference, we shall find that the relation is more distinctly representable, and more enduring in memory, than are its terms.

Naturally, this truth is the least conspicuous among the most relational feelings, since these being highly revivable, there is a comparatively small margin for difference between their revivability and that of the relations between them. Still the difference may even here be perceived. If we recall a room frequented in childhood, the relative positions of the door, the windows, the fireplace, arise in consciousness instantly: we may or may not think of some of the colours, but if we do, it is by a subsequent act. Similarly with the tactually-disclosed co-existent impressions which we remember as a knife-handle. The combination of these constituting the conception of its shape, recurs more readily in thought than does the particular intensity of any one of the pressures, or than does the particular feeling of coldness.

With relations of sequence as exhibited among the auditory feelings, this contrast is more decided. To begin an air in the right key, most persons find very difficult: without the help of an instrument, the first note is often wrong by a third or even a fifth. But the duration of the first note is more nearly remembered. Though the time at which the air is taken may differ somewhat from the time as originally heard, it does not differ so much as the pitch. It is further observable, as showing the same thing, that while the rhythm of a melody may be repeated in thought with great exactness, we cannot delight ourselves by recalling with the same exactness the rich timbre of the tones in which we heard the melody rendered.

When we descend to the least relational feelings, the greater revivability of relations than of their terms becomes very manifest. We remember for a long time with accuracy the spot in which an acute pain was felt, though the pain itself is not representable with anything like its original acuteness; and if the pain was a throbbing one, we can recall its intervals with approximate correctness. So, too, is it with the central feelings. The succession of certain strong emotions passed through yesterday, is easier to recall than the emotions themselves. It is the same with the relation of each emotion to its antecedents. The circumstances under which we were angry may be reproduced in consciousness instantly; but the anger itself cannot be reproduced instantly.

It is worth considering whether the possibility of extended and complex thinking does not in part depend on this greater revivability of relations than of their terms.

We habitually pass in thought from concept to concept, briefly recognizing the essentials of each—the essential relations of its elements to one another and to other things. If the feelings between which all these relations exist arose in consciousness with as much promptness and vividness, consciousness would be so encumbered with materials that involved processes of reasoning would be greatly impeded, if not prevented.

§ 106. As different orders of feelings are more or less relational, so, too, in a sense, different orders of relations are more or less relational. For just as some kinds of feelings are more capable of entering into relations with one another than other kinds are, so some kinds of relations are more capable of entering into relations with one another than other kinds are. Understanding the expression in this sense, we may say that the most relational of relations are those of Co-existence. Co-existences may be trebly compounded, and are, indeed, trebly compounded in most acts of thought: impressions are presented and represented in those triple relations of position involved in the conception of place. Sequences are much less relational; for they can enter into relation with one another not in three directions at once, but only in one direction. Successive intervals of time stand related to one another as greater, or less, or equal; and in the beats and bars of music, these relations of equality and difference in portions of time are themselves compounded into other relations—relations, however, which are essentially serial. The least relational of relations are the primary ones—those of Difference; for though these enter into relations with one another whenever we contemplate two differences as equal, or more or less unequal, in degree, yet (unless it be in the higher divisions of Mathematics) they do not enter into relations more compound than these.

This description of the several classes of relations as more or less relational, is introductory to the fact here to be set down, that just as the most relational of feelings are the most revivable, so, too, are the most relational of relations the most revivable. Relations of Co-existence, whether we take any particular plexus of them constituting the perception of a form, or whether we take the aggregate of them constituting the consciousness of Space, have a revivability far exceeding that of all other relations. We think of distances, of directions, of sizes, of shapes, of arrangements among objects, with little or no effort and with great clearness; and these variously-compounded relations we conceive as frameworks which we can imagine to be occupied by other objects, or to be unoccupied. The revivability of relations of Co-existence is, indeed, so extreme that they cannot be wholly suppressed—an assemblage of them greater or less in extent, partly occupied and partly unoccupied, forms an inextinguishable element of consciousness.

Relations of Sequence, less relational than those of Co-existence, are less revivable. Though it is true that, as organized into the abstract conception of Time, relations of Sequence can no more be wholly excluded from consciousness than those of Co-existence, yet, as thus abstracted, they do not form so dominant an element of consciousness: the integrated aggregate of space-relations habitually present in thought, is much larger and much clearer than the integrated aggregate of time-relations. It is observable, too, that particular space-relations are more clearly and correctly representable than particular time-relations. We can mark out with greater accuracy the length of an inch or of a foot, than we can assign the length of an interval as being one minute or as being ten minutes.

Simple relations of Difference (those between feelings) are neither so readily nor so accurately revivable as relations of Difference between co-existences or between sequences, nor as the relations of Co-existence and Sequence themselves. We can better remember the proportion between two lengths which we observed simultaneously, and can more truly reproduce in thought the ratio between the rhythms of movements in a machine, than we can recall the degree of contrast between two lights we saw or two weights we lifted; and where the differences are between the unrelational feelings, as tastes, and smells, and visceral sensations, we can recall them but vaguely.

§ 107. As presented feelings hinder the representation of other feelings, so do presented relations hinder the representation of other relations; but they do this in a smaller degree. It is with relations, too, as with feelings, that the antagonism of the presented to the represented is more manifest between those of the same order than between those of different orders. Omitting superfluous illustrations, we will note a few distinctive traits only.

Among the most relational relations, as among the most relational feelings, the present impedes remembrance of the past in the smallest degree; and among these, too, we find presented relations interfering in the smallest degree with the representation of relations of the same order. Visual relations, no matter how vividly impressed, never absolutely exclude from consciousness other visual relations of which we choose to think. We saw that a very intense visual feeling temporarily prevents us from calling to mind another visual feeling; but though it is impossible to gaze at the sun and think of green, it is quite possible to gaze at the sun and think of a square. Similarly, a trial will show that if while contemplating any scene we think of some other scene, we recall the distribution of its parts more readily than we recall its colours.

Relations of Sequence, much less relational as they are, show us a greater interference of the present with remembrance of the past. Though while looking at one shape we can easily think of another quite unlike it, we cannot, without difficulty, if at all, call to mind a rhythmical combination of intervals wholly different from another to which we are listening—cannot bring into consciousness the movement of a melody in $\frac{3}{4}$-time while listening to a melody in common time. When the rhythm we hear is very simple, as the splash of oars while rowing, it is, indeed, possible to think of some complex rhythm disagreeing with it entirely; but only the disciplined musician can attend at once to ideal and real rhythms that are both complex and quite unlike one another.

It is obvious that presented relations of Difference between simple feelings, stand very much more in the way of represented relations of Difference between simple feelings—especially where the differences are between feelings of the same order.

§ 108. A kindred truth to be here noticed (the counterpart to which should have been noticed when dealing with the revivability of feelings) is that the representation of any relations is hindered by the presence in consciousness of other represented relations; and that the hindrance, while either great or insuperable if the two sets of relations are of the same order, is comparatively small if they are of different orders.

The most relational of relations may be superposed in thought, one set upon another: we can imagine the outlines of a face, and then, without losing consciousness of it, may imagine a geometrical figure described over the same visual area. We cannot, however, deal similarly with unlike sets of sequences. The rhythm of some tune which has taken possession of us, and of which we vainly try to rid ourselves by thinking of other things, may be effectually expelled by rehearsing in thought another tune.

But when the relations are of different orders, their representations have but little power of mutual exclusion. We see this in the case just referred to; for the tune that pesters us keeps running on through consciousness while we are thinking of places, or actions, or matters of business. Hence, too, results the frequent failure of the receipt for obtaining sleep when excited—that of counting; for after a short time the counting becomes almost automatic, and is carried on while consciousness is still chiefly occupied by the exciting thoughts.

§ 109. From the mental conditions that affect the revivability of relations, we pass now to the physical conditions that affect their revivability. As might be expected, those which hold with feelings hold also with the relations between feelings. It is needless to trace out their influences as fully as before. A single illustration of each will suffice.

Proof that relations established in consciousness at a time when the nervous centres are worn by long-continued action, have a comparatively small revivability, is furnished by the familiar experience that knowledge acquired by "cramming" is soon lost. That relations impressed when the circulation is vigorous are more revivable than those impressed when the circulation is feeble, we see in the decaying receptivity of age. During youth and early manhood, it is easy to recall the various events on each of the successive days recently passed, and there is never any doubt what is the day of the month; but as life advances and the heart's action flags, these relations of recent times and actions quickly fade. Similarly, relations impressed when the circulation was strong and that were once easily recallable, become difficult to recall when the circulation has been rendered abnormally feeble. Thus, it is a common symptom with nervous subjects to make mistakes in spelling quite simple words; and in states of extreme prostration such persons, as well as those greatly reduced by illness, forget where they are, and even who they are.

Quality, as well as quantity, of blood has an influence.

A fact before referred to as illustrating the relativity of relations, may here be again named as illustrating the variations of their revivability thus caused—the fact, namely, that opium produces intensified and exaggerated representations of spaces and times.

§ 110. On comparing these subjective truths with the objective truths presented by the nervous system, we may trace, as in other cases, a general congruity.

That relations of any order, presented or represented, greatly hinder, or wholly prevent, the representation of relations of the same order, but hinder much less, or scarcely at all, the representation of relations of other orders, might be inferred from the data with which we set out. If, through a plexus of nerve-fibres, there is propagated the particular set of nervous discharges which answer physically to what is psychically a certain set of perceived or conceived relations, an obstacle is thereby put to the simultaneous propagation through them of a different set of nervous discharges answering to a different set of conceived relations. But a separate plexus of nerve-fibres, the discharges through which answer to relations of another order, may be simultaneously excited without producing the same confusion, and may yield to consciousness its partially-independent train of ideas—partially-independent we must say, because the actions of the two plexuses having to be co-ordinated at some common centre (for otherwise the corresponding ideas would not belong to one consciousness) there must always result some interference.

That the revivability of relations varies with the state of repair of the nervous centres and the supply of blood to them, is also a fact harmonizing with physiological inference. For be it high repair, or much blood, or special quality of blood, it is clear that whatever conduces to a powerful nervous discharge through any plexus of nerve-fibres, the physical changes in which answer to the psychical changes known as certain relations, must cause a corresponding vividness of the relations—must alike give great clearness to the consciousness of the more familiar relations of the cluster, and bring into consciousness those remoter and less frequently-repeated relations of the cluster which, with feebler nervous discharges, would not come into consciousness at all.

CHAPTER VII.

THE ASSOCIABILITY OF FEELINGS.

§ 111. In preceding chapters, a good deal has been said by implication about the phenomena usually treated under the head of Association. When tracing out the composition of Mind, we saw that feelings cohere in unlike degrees in different tracts of consciousness; and what were there described as cohesions may be otherwise described as associations. More recently, too, in the chapter on the Revivability of Feelings, much was tacitly asserted respecting the Associability of Feelings; since, other things equal, revivability varies as associability.

The truths thus observed from points of view already passed, we must nevertheless here briefly glance at afresh from a more advanced point of view, before we go on to consider certain further truths covered by the title of this chapter.

§ 112. We divided feelings into the central, commonly called emotions, and the peripheral, commonly called sensations; which last we re-divided into those internally initiated, which we may conveniently call ento-peripheral, and those externally initiated, or epi-peripheral. Of these three great groups of feelings the first are extremely unrelational; the second are somewhat more relational; and the third are relational in a comparatively high degree. Beginning with the central or least relational feelings, which have no limitations in space and are but vaguely bounded in time, we found that, passing through the ento-peripheral to the epi-peripheral, we come to feelings more and more definitely limited by one another in space, or time, or both: the sharpest limitations being among the feelings that are epi-peripheral in the highest degree. And along with this increasing definiteness of mutual limitation we saw that there goes an increasing tendency to mutual cohesion.

This, then, represents the order of associability of the feelings. The relational are the mutually-limited, which are the mutually-coherent, which are the associable. Feelings of the central or of the ento-peripheral kinds which have been experienced together or in succession, either do not recall one another into consciousness at all or do it but feebly after many repetitions; while feelings of the epi-peripheral kind which occur together or in succession but a few times, become linked in such a way that the vivid or the faint form of one arouses the faint forms of the rest.* Indeed among the auditory and visual feelings, single presentations in serial or simultaneous groups cause such connexions, that one member of a group being afterwards presented or represented, representations of the other members follow it, often with few or no omissions.

Manifestly, associability and revivability go together; since, on the one hand, we know feelings to be associable only by the proved ability of one to revive another, and since, on the other hand, the revival of any feeling is effected only through the intermediation of some feeling or feelings

* Though a vivid or faint antecedent feeling usually brings into consciousness as its consequent only a faint feeling, yet it is not true, as commonly supposed, that the consequent is never a vivid feeling. Ideas do, in some cases, arouse sensations. Several instances occur in my own experience. I cannot think of seeing a slate rubbed with a dry sponge without there running through me the same cold thrill that actually seeing it produces.

with which it is associated. Hence the conditions that favour revivability are those which favour associability. These, both psychological and physiological, having been enumerated in the last chapter, may be passed over.

§ 113. There remains to be here considered the ultimate law to which the association of feelings conforms. Leaving out all the variable concomitants of any simple association, there are two constant elements directly presented by it—the feelings and the relations between them; and two constant elements indirectly implied by it—previously-experienced similar feelings and previously-experienced similar relations. Hence, respecting the structure of the entire cluster, there arises the question—Which are the primary or original connexions and which are the secondary or derivative connexions? For, to use a symbolic illustration, it may happen that in the coherent cluster $\begin{array}{cc} a & b \\ | & | \\ c & \!\!\!-\!\!\! d \end{array}$ the elements *a*, *b*, apparently held together by some bond, are not themselves connected at all, but are kept in juxtaposition by the links which hold them respectively to the coupled elements *c-d*. Let us state the matter more specifically.

The consciousness of two feelings presented together, or one just after the other, implies, first, the consciousness of each feeling as such or such—implies recognition of it as like, in some or all of its characters, to a feeling previously experienced. Even where one of the two feelings (say the taste of a new wine or of a new drug) is unexperienced, it is still assimilated to some genus of feelings—is known as sweet, or bitter, or sour. The consciousness further includes two relations between the feelings—their relation of difference, and their relation of co-existence or of sequence; and the knowing each of these relations as such or such implies past like relations to which it is assimilated. Now the question to be asked is, whether the association established between the two feelings results immediately from the cohesion of the one to the other, or results mediately from the cohesion of each feeling and each relation between them, to their respective similars in experience. The usual supposition is that the cohesion is immediate; but we shall find good reason for concluding that it is mediate. The inquiry is divisible into two inquiries—how the feelings, past and present, comport themselves towards one another, and how their relations, past and present, comport themselves towards one another. These must be dealt with apart, though some inconvenience attends the separation of them; for neither can be fully answered without both being answered. Such large gaps as the instructed reader perceives in this chapter on the Associability of Feelings, he will find filled up in the next chapter on the Associability of the Relations between Feelings.

This premised, let us consider in what way feelings, real and ideal, behave when separated, so far as may be, from particular relations.

§ 114. Members of the three great groups of feelings severally associate themselves primarily with members of their own group. Of the central feelings, or emotions, this proposition is less manifestly true than of the rest, for the sufficient reason that they are the least relational of feelings: cohering but little with feelings of any kinds, the differences in their cohesive tendencies are the least decided. Still, it is observable that a central feeling when it arises, is known as belonging to the class we call emotions, and not to the class we call sensations. Peripheral feelings being all localized, vaguely if not definitely, these central feelings, not being localized, are in this respect antithetical to them; and each, in the act of recognition, aggregates with the class of unlocalizable feelings, instead of with the class of localizable feelings. It is true that in consequence of the disturbances of certain viscera which powerful emotions produce, the ento-peripheral feelings thence resulting, are, in common speech, partially confounded with the central feelings; but though the sensation due to disturbed action of the heart is often metaphorically identified with the emotion causing the disturbance, yet every one really distinguishes between the consequence and the cause, and classes the cause apart. When we pass to the ento-peripheral feelings it is at once obvious that each, in the instant of presentation, is known as initiated within the body. Be it one of the least localizable of these feelings, such as hunger, or be it a more localizable one, such as a pain in the bowels, or be it one localizable with comparative definiteness, as an ache in the finger, it is, as having a place more or less bounded within the bodily framework, at once separated in consciousness from the central feelings on the one hand and from the epi-peripheral feelings on the other. The only cases where this association is indefinite, are cases where the feeling is initiated near the division between the two kinds of peripheral feelings; as when an itching just below the surface is confounded with a tickling upon the surface, or as where the sensation of heat due to sub-cutaneous congestion is undistinguished from the sensation of heat due to adjacent hot matter. The epi-peripheral feelings show us this instant integration of each with its class, even more conspicuously. The sensation produced by a blow, by something grasped, by an odour, by a flash, or by a sonorous vibration, cannot arise in consciousness without being grouped with the general assemblage of sensations initiated at the surface and ascribed to objective actions. The association is not a matter into which thought or will enters: it is instantaneous and absolute.

A further fact of kindred meaning may now be noted. Each feeling as it arises associates itself instantly not with its class only, but also with its sub-class. The central feelings are but indefinitely divisible into sub-classes; and hence among them there is but little manifestation of this truth. We may pass over them. The ento-peripheral feelings illustrate this sub-classification and cohesion quite clearly. On thrusting itself into consciousness, one of these, while known as originating within the body, is at the same time known as a craving, or as a pain, or as a muscular strain: it falls into its secondary group while falling into its primary group. Similarly with the epi-peripheral feelings. A colour the moment it is perceived, not only irresistibly aggregates with the class of feelings that originate on the outer surface and imply outer stimuli, but also with the sub-class of visual sensations, and cannot be forced into any other sub-class. While being recognized, a sound falls simultaneously into the general assemblage of feelings derived from the senses which hold converse with the external world, and also into the more special assemblage of feelings distinguished as auditory; and no effort will separate it from this special assemblage. And to say that a smell cannot be thought of as a colour or a sound, is to say that it associates itself indissolubly with previously-experienced smells.

A sub-sub-classification of like nature is no less instantaneous. This is traceable to a considerable extent among the feelings excited within the body: hunger is at once known as hunger and not as thirst; an acute pain coheres in thought with acute pains, and not with what we distinguish as aches. But it is among the feelings yielded by the special-sense organs that the sub-sub-classing is most conspicuous. When we look at the sky, we think of its colour as a feeling of external origin, as belonging to the sub-division of externally-originated feelings called visual, and also as belonging to the group of these called blues: it does not suggest reds or yellows, and refuses to unite with them in consciousness. A mouse's squeak assimilates itself in thought with sounds of high pitch, and not with sounds like the bellowing of a bull. The taste of honey aggregates with sweet tastes in general, of which it is one—not with such tastes as those of quinine, or of castor oil.

There is a still greater speciality of these associations; as where bright colours of each kind connect themselves in thought with bright colours of the same kind and not with dull ones, or as where loud sounds of any pitch suggest other loud sounds of that pitch and not faint ones. But without further instances the reader will see that the law holds down to the minutest sub-divisions of kind and quality.

§ 115. What is the most general statement of these facts? It is that be there or be there not any other kind of association, the primary and essential association is between each feeling and the class, order, genus, species, and variety, of preceding feelings like itself.

This association is automatic—is not an act of thought that may or may not take place, but constitutes the very recognition of each feeling. A feeling cannot form an element of Mind at all, save on condition of being associated with predecessors more or less the same in nature. In the process of this automatic association each feeling coheres instantly with the great group to which it belongs; instantly, too, with its sub-group within this; and, among the relational feelings, goes practically at the same time into its sub-sub-group. The automatic character of the process is qualified only when we come to the smallest groups, its association with one or other of which may occupy an appreciable interval. Thus, the sensation of red passes in a moment to its class as epi-peripheral, in the same moment to its order as visual, and with equal rapidity to the genus of colours distinguished as reds; but it falls into the species known as scarlet or that known as crimson less promptly, and it is a matter of deliberation and uncertainty whether we think of it as like the scarlet of a soldier's coat or like that of a poppy—like the crimson of a peony or like that of a carnation.

Now this cohering of each feeling with previously-experienced feelings of the same class, order, genus, species, and, so far as may be, the same variety, is the sole process of association of feelings. All other phenomena of association of feelings are consequent on the union of this process with a parallel and simultaneous process to be described in the next chapter.

§ 116. Before passing to this next chapter, let us briefly note the congruity between these facts disclosed by introspection and the facts disclosed by outward observation, which were set down among our data.

The associability of feelings with those of their own kind, group within group, corresponds to the general arrangement of nervous structures into great divisions and subdivisions. The central feelings arise within the great cerebral masses; and the subjective connexion shown in the instant association of each with its class, answers to the objective connexion between one set of nervous actions occurring in these great masses and other sets of nervous actions that have occurred in the same masses. The peripheral feelings, again, initiated by disturbances upon or within the body, have their seat in the subjacent nervous mass (or masses, but probably the *medulla oblongata* is the sole sensational centre); and the classing of one of these feelings with sensations in general, instead of with emotions, answers to the connexion between one nervous change in this subjacent mass and other nervous changes in it. Similarly with the leading sub-classes. The particular parts of that developed end of the spinal cord in which peripheral feelings of unlike kinds are localized, remain at present undetermined. But if we remember that great sub-classes of the peripheral feelings, as the visual, have great bundles of nerve-fibres which carry the disturbances arousing them from surface to centre, and that other such great sub-classes, as the auditory, have other such bundles, we may be sure that each sub-class of peripheral feelings has its own sub-division of central vesicular structure. And if so, the instant automatic aggregation of each peripheral feeling with those of its own order, answers psychically to the localization of the nervous excitement causing it, within that sub-division of vesicular structure which is the seat of other feelings of its order. That the like holds of still smaller groups of feelings and clusters of vesicles, is an obvious inference.

What is the implication? If the association of each feeling with its general class, answers to the localization of the corresponding nervous action within the great nervous mass in which all feelings of that class arise—if the association of this feeling with its sub-class, answers to the localization of the nervous action within that part of this great nervous mass in which feelings of this sub-class arise, and so on to the end with the smallest groups of feelings and smallest clusters of nerve-vesicles; then, to what answers the association of each feeling with predecessors identical in kind? It answers to the re-excitation of the particular vesicle or vesicles which, when before excited, yielded the like feeling before experienced. The appropriate stimulus having set up in certain vesicles the molecular changes which they undergo when disturbed, there is aroused a feeling of the same quality with feelings previously aroused when such stimuli set up such changes in these vesicles. And the association of the feeling with preceding like feelings, corresponds to the physical re-excitation of the same structures. Whence we see clearly that the ultimate law of association of feelings, as above described, has a definite physical counterpart; and that there is no room for any other law of association of feelings.

CHAPTER VIII.

THE ASSOCIABILITY OF RELATIONS BETWEEN FEELINGS.

§ 117. The associability of relations, like the associability of feelings, has been to some extent implicitly dealt with under preceding heads. When considering the composition of Mind, we saw that relations as well as feelings cohere with one another in consciousness; and what was there described as cohesion of relations is otherwise describable as association of relations. Again, in the last chapter but one, different classes of relations were observed to be revivable in different degrees, which implies that, other things equal, they are associable in different degrees. Moreover, we saw how the revivability of relations varies in degree according to the fulfilment of sundry conditions, psychical and physical; whence it follows that their associability similarly varies.

Though these truths need not be again contemplated in detail from our present point of view, there are one or two leading aspects of them which we must glance at before passing on to the general law remaining to be set forth.

§ 118. That the most relational of relations are the most associable is a truism; for the relations which enter into relation with one another most easily are the relations most easily associable with one another.

The most relational of relations are, as we before saw, those of Co-existence as visually presented; and these are associable with extreme facility. We sleep in a strange bedroom, and getting up in the dark to reach the water-bottle, recall at once the position of the washing-stand. We read a book, and without having specially observed the fact, remember that a passage we want to find lies near the bottom of a left-hand page. So quickly do these relations of co-existent positions connect with one another, that those of many things seen at the same instant can be simultaneously reproduced in thought.

Relations of Sequence are associable into simple combinations with considerable facility, though with less facility. Two or three successive motions made by a person we are watching are readily remembered, though we fail to remember the order of many such motions. After hearing the first bar or the first phrase of a new melody, it is easy forthwith to repeat the rhythm in thought; but the series of rhythms which the entire melody presents, do not (in most minds at least) recur correctly without repetitions more or less numerous. This smaller associability is, however, chiefly shown in the contrast between our ability to recall many co-existences presented together, and our inability to recall many sequences presented together. We look into a room and instantly connect in consciousness the relative positions of two or three persons, the table, the sofa, &c., so that we can afterwards describe how they stood; but we cannot in the same way take in at a glance, and reproduce in thought, the several combined movements of a horse in trotting: we can clearly think of the alternate swings of the fore-legs by themselves or of the hind-legs by themselves; but, unless after specially observing it, we cannot remember which hind-leg comes to the ground after the near fore-leg.

There is considerable associability of co-existences with sequences—those sequences, at least, in which the co-existing positions composing Space are traversed in successive instants of Time. This association of relations, underlying as we shall hereafter see our conceptions of Space and Time, leads by perpetual repetition to indissoluble connexions in consciousness, which govern our thoughts absolutely. It will be instructive here to observe how multitudinous experiences have so fused together certain of these relations, that one being presented brings up the consciousness of the other spite of every effort to exclude it. Let us take an instance. We move about day by day on foot and in vehicles, perpetually passing objects, some of them also moving, but most of them stationary. In all these cases there is relative motion, which, as visually perceived, is, other things equal, the same whether it results from the motion of the subject while the object is stationary, or whether it results from the motion of the object while the subject is stationary. Ordinarily we can distinguish between these two causes of relative motion. The relative motion of stationary objects is always accompanied by the consciousness of either our own locomotive activity or the activity of something carrying us—the action of the horse, or the jolting of the carriage, or both. Conversely, when relative motion is seen while we are stationary, we habitually see along with it those vital or mechanical actions which cause locomotion. Hence the relative motion of adjacent objects which do not exhibit any of the direct or indirect concomitants of locomotion, comes to be strongly associated in thought with our own motion; and, unless other perceptions furnish evidence to the contrary, the perception of relative motion under such conditions causes an irresistible consciousness of our own motion, even when we are motionless. This is remarkably illustrated when sitting in a train at a railway station with another train standing along-side in such way as to exclude the view of all other objects (so shutting out contradictory evidence). When one of the two trains starts, the relative motion which we perceive on looking at the other train is just as likely to be due to the starting of the other train as to the starting of our own. But the tendency always is to think that our own train is moving. Continually we find ourselves wrong; but the knowledge of the fact that under these conditions the sense of our own motion is often illusive, does not enable us to exclude it. The association of these relations has become automatic, and the resulting organic inference, taking possession of consciousness, retains it until some decisive contradictory impression suddenly, with a shock, dispels it.

§ 119. Before seeking the ultimate law of association of relations, let us observe how relations, like feelings, aggregate with their respective classes and subclasses.

When we see two things, or two parts of a thing, simultaneously, the relation between them automatically classes itself with relations of Co-existence in general. We cannot prevent it from cohering with that great division of relations the terms of which do not differ in their order of presentation—space-relations. So, too, when watching the motion of a body from one place to another, when listening to successive words, or when perceiving light after striking a match, the relation between the states of consciousness produced, instantly and irresistibly associates itself with Sequences. To be conscious of the relation at all, is to be conscious of it as belonging to that great division of relations the terms of which differ in their order of presentation. It automatically classes itself with time-relations. Equally, the observation of a difference between two impressions, whether simultaneous or successive, implies its assimilation to Differences in general. While in the order of its terms the relation can be known at all only as a relation of co-existence or sequence, its terms can be known at all as standing in relation, only by distinguishing between them in consciousness; and the act of distinguishing between them is the act of classing their relation along with relations of Difference.

At the same time each relation passes into one or other of certain sub-classes. A co-existence between visual feelings, unites itself rigidly with that marvellous aggregate of relations constituting our consciousness of visually-perceived space. But when two impressions are simultaneously received from things touched in the dark, the relation between them, while it coheres with the general class of co-existences, coheres with the sub-class of tactually-perceived co-existences—a sub-class constituting a comparatively rudimentary consciousness of space, which, though it arouses an ideal-consciousness of visually-known space, differs wholly in quality from this. And the thing to be noted is, that a tactually-perceived relation of co-existence is never confounded with a visually-perceived one; but is only, by a comparatively deliberate act of thought, remembered to have the same objective equivalent. Relations of Sequence associate themselves into the sub-classes of internal and external. This classification of them necessarily accompanies the classification of their terms. The sequences between internal feelings and those between external feelings, are, in the act of knowing the feelings as inwardly or outwardly initiated, distinguished as sequences belonging to the Ego or sequences belonging to the Non-ego; and no member of either group is transferable to the other. The instantaneous sub-grouping of relations of Difference scarcely needs pointing out. We observe two heights or two breadths to be unlike, and in thinking them unlike think of their difference as a difference in space-occupancy—cannot think of it as a difference between times or intensities. In being conscious of two notes in music as standing to one another in the ratio of minim and crotchet, the unlikeness between their lengths is cognizable only as an unlikeness between portions of time. And similarly, the contrast in strength between two colours or two tastes, passes in the moment of perception into the sub-class of contrasts in intensity—refuses to be thought of as a contrast in dimension or duration.

Among space-relations may be observed a further stage of this process. Though they have no sub-sub-classes divided as definitely as are the sub-sub-classes of certain feelings, especially the epi-peripheral; yet they are habitually thought of as belonging to vaguely-distinguished assemblages which have reference to the arrangements of the limbs and senses. In the moment of perception a visual relation of co-existence falls into that aggregate of such relations composing the consciousness of the space before us—cannot be associated with the aggregate of such relations composing the vaguely-conceived space behind us. In like manner the relation at once coheres with the still more special group of relations constituting the space we distinguish as above, or the space we distinguish as below; and it is at the same time automatically classed with space-relations to the right or to the left. Only when it is very near to the ideal boundaries we make between these regions of space, may there be an association of it with some other than its own group.

We are now in a position to appreciate the significance of the ultimate segregations. On looking, say at a flower by the roadside, the relations among the feelings of colour which we receive from its petals, instantly associate themselves with relations of Co-existence in general, with the sub-class of visually-perceived relations of co-existence, with the sub-sub-class of these relations forming the space in front of us, and with the still smaller group of these relations aggregated into our conception of the space low down to the right. But they do more than this. With equal, or with almost equal, rapidity, (I say almost equal because this minor classification varies in rapidity with the goodness of the vision) these relations of co-existent positions presented by the petals of the flower, associate themselves in consciousness with the relations of co-existent positions constituting the space immediately about the flower—the particular portion of space that is not only the same in direction but the same in distance. For, on observing what happens when the axes of the two eyes are converged on an object, it will be perceived that we become conscious of the space it occupies, and of the closely-environing space, with much more distinctness than we are conscious of any other space. Under such conditions we are scarcely at all conscious of the space behind us; we are scarcely at all conscious of the space far beyond the object, if opaque matter shuts out impressions from things contained in it; we are conscious in but a vague way of the space far to the right or to the left, much above or below; we are conscious with some clearness of the space between our eyes and the object, so far as this consciousness is involved in the conception of distance; but we have what may be called a detailed consciousness of the space in and around the object. It needs only to look now at a thing quite near and now at a thing further off, now at one on this hand and now at one on the other, to perceive that the respective portions of space in which they exist, severally become indistinct in consciousness as we turn our eyes away; and that distinctness in our consciousness of each portion of space, results only when the eyes yield a distinct image of something placed in it. That is to say, any co-existing positions visually presented are immediately associated in thought with the cluster of co-existing positions similarly related to us—each perceived position standing in a relation of co-existence with self, associates itself most closely with other positions standing in like relations of co-existence with self. And in being classed with these relations which it is most like, it arouses a consciousness of them; just as a colour in being recognized as red of a particular shade, brings into consciousness ideas of other reds of the same, or nearly the same, shade. Moreover, as we before saw that while a particular feeling of redness associates itself irresistibly and in a moment with the great class of epi-peripheral feelings, with the sub-class of visual feelings, with the sub-sub-class of reds, but less quickly with its particular variety of reds; so here we may see that while this relation of co-existent positions associates itself instantly and rigidly with relations of co-existent positions in general, with visual relations of co-existent positions, with the relations of co-existent positions constituting the region of space low down to the right, it associates itself less promptly with the relations of co-existent positions that are almost identical: there is some uncertainty in the estimation of the distance—an uncertainty which is considerable in a person with but one eye, who continually finds himself wrong, and has to modify his estimate, or to re-class the relation. This general law may be similarly traced among time-relations. Suppose I recall an event that occurred yesterday; as, for instance, the unexpected arrival of a friend. It is observable, in the first place, that all those associated and consolidated relations of sequence which constitute the conception of the time before yesterday, do not (unless by some secondary act) enter into consciousness at all. It is observable, in the second place, that the united relations of sequence which form a conception of the time between now and yesterday, are not distinctly represented, but are represented only in such general way as to yield a measure of the distance back at which the event occurred. While it is observable, in the third place, that the portion of time to which retrospective consciousness is directed, becomes comparatively distinct in detail. On remembering the first sight of my friend's face yesterday, I think not only of his smile of recognition, of my quick step towards him, of our shaking hands, of the words that followed, but I also think of the immediately-preceding occurrences—of my entrance into the room, of my seeing the back of some person looking at a picture, of his turning round on hearing me, of my surprise on seeing who it was. I find, too, that the moments immediately adjacent to any one of these remembered actions, become more distinct in consciousness than those at some distance on either side of it. If I recall my entrance into the room, the positions in time which made up the interval before my friend turned round, represent themselves quite clearly—far more clearly than those preceding his knock at the door or those succeeding our salutation. To make these portions of time equally clear, I must adjust my retrospective glance to positions adjacent to them. Thus it is with Time as with Space, that each place in it associates itself with places at the same distance from the place we at present occupy; and as we turn our attention now to one part of the past and now to another, the relations of sequent positions which constitute our consciousness of that part become clear, while all others lapse into vagueness.

§ 120. Every relation then, like every feeling, on being presented to consciousness, associates itself with like predecessors. Knowing a relation, as well as knowing a feeling, is the assimilation of it to its past kindred; and knowing it completely is the assimilation of it to past kindred exactly like it. But since within each great class the relations pass one into another insensibly, there is always, in consequence of the imperfection of our perceptions, a certain range within which the classing is doubtful—a certain cluster of relations nearly like the one perceived, which become nascent in consciousness in the act of assimilation. Along with the perceived position in Space or Time the contiguous positions arise in consciousness.

Hence results the so-called Law of Association by Contiguity. When we analyze it, Contiguity resolves itself into likeness of relation in Time or in Space or in both. Let us observe how in the association of like relations there is involved the association of contiguous feelings.

On the one hand, relations of difference and the time-relations implied in the cognition of successive differences, are elements without which there can be no consciousness. On the other hand, there can be no consciousness of these relations without consciousness of some feelings which simultaneously yield them. We can think of space-relations, all but absolutely empty, but we cannot think of anything approaching to empty time-relations. Time having but one dimension, and the measure of that dimension being the series of contained feelings, it follows that unless occupied by some feelings, real or ideal, Time has no dimension. If the objects around are perfectly stationary and silent, we have still the rhythm of our functions and the current of our thoughts to yield us marks by which to measure duration. Necessarily, then, when we think of any position in past time, we cannot associate it with its cluster of almost equidistant positions in time, without being conscious more or less clearly of the feelings which occupied those almost equidistant or contiguous positions. Association of feelings contiguous in time, is involved by association of their like time-relations. Passing to contiguous co-existent feelings, we may see that the association of them results from a further complication of the same process. Feelings known in sequence, and serving as marks that measure duration, may be sounds or odours which do not necessarily connote Space at all in a rudimentary consciousness. But in a consciousness containing tactual and visual experiences, there always, along with the sequent feelings caused by inner or outer changes, occur certain feelings, received by touch or sight or both, which continue to co-exist while the sequent feelings are passing. These simultaneously-experienced feelings yielded by things contiguous in space, which persist side by side in consciousness over an appreciable period measured by sequent feelings, are necessarily associated with these in their time-relations. Hence on recalling any relations of sequence, there are apt to recur the various relations of co-existence which were perceived along with them. And the feelings that occupied these nearly equi-distant positions in space that were presented in these nearly equi-distant positions in time, being among the feelings which made marks in consciousness at that time, the representation of that time entails a recurrence of these marks.

The process thus described as taking place with simple relations having simple feelings for their terms, equally holds in a plexus of relations among many feelings; as in the perception of an ordinary object. When, for instance, in recognizing a face we saw last week, we associate each of the many combined relations of position constituting its form, with the respective like relations before experienced; and when along with the recognition there arises the consciousness of a redness on the cheek that was before present but is now absent; this recollection of the colour that occupied a particular place, results simply because it was one of the elements entangled in the plexus of relations which gave the consciousness its individuality. On before seeing the face, this colour was a term to various relations of difference involved in the consciousness; it was presented at the same instant of time with the many other related feelings which the consciousness contained; and as having a position fixed in reference to all parts of the face, it entered into a great number of relations of co-existence. Hence, having served as a common term to many different but combined relations, it happens that when these are again presented, the assimilation of them to the like relations before seen, entails a consciousness of the missing term of these like relations before seen. The colour is thought of in thinking of the relations; and the difference between the face as remembered and the face as perceived becomes manifest.

Thus, the fundamental law of association of relations, like the fundamental law of association of feelings, is that each, at the moment of presentation, aggregates with its like in past experience. The act of recognition and the act of association are two aspects of the same act. And the implication is that besides this law of association there is no other; but that all further phenomena of association are incidental.

§ 121. The congruity between this conclusion and the facts of nervous structure and function is evident.

Changes in nerve-vesicles are the objective correlatives of what we know subjectively as feelings; and the discharges through fibres that connect nerve-vesicles are the objective correlatives of what we know subjectively as relations between feelings. It follows that just as the association of a feeling with its class, order, genus, and species, group within group, answers to the localization of the nervous change within some great mass of nerve-vesicles, within some part of that mass, within some part of that part, &c.; so the association of a relation with its class, order, genus, and species, answers to the localization of the nervous discharge within some great aggregate of nerve-fibres, within some division of that aggregate, within some bundle of that division. Moreover, as we before concluded that the association of each feeling with its exact counterparts in past experience, answers to the re-excitation of the same vesicle or vesicles; so here we conclude that the association of each relation with its exact counterparts in past experience, answers to the re-excitation of the same connecting fibre or fibres. And since, on the recognition of any object, this re-excitation of the plexus of fibres and vesicles before jointly excited by it, answers to the association of each constituent relation and each constituent feeling with the like relation and the like feeling contained in the previous consciousness of the object; it is clear that the whole process is comprehended under the principle alleged. If the recognized object, now lacking one of its traits, arouses in consciousness an ideal feeling answering to some real feeling which this trait once aroused;

the cause is that along with the strong discharge through the whole plexus of fibres and vesicles directly excited, there is apt to go a feeble discharge to those vesicles which answer to the missing feeling, through those fibres which answer to its missing relations, involving a representation of the feeling and its relations.

CHAPTER IX.

PLEASURES AND PAINS.

§ 122. The foregoing chapters contain such an outline of the Inductions of Psychology as the plan of this work requires. To fill in this outline would take more space than can be afforded, and would too much interrupt the general argument.

There is, however, one other side of mental phenomena as inductively generalized, which cannot be omitted without leaving this outline incomplete. Thus far we have spoken of Feelings as central or peripheral, as strong or weak, as vague or definite, as coherent or incoherent, as real or ideal; and where we have considered them as differing in quality, the differences named have been such as do not connote anything more than a state of indifference in the subject of them—a passive receptivity. But there are certain common characters in virtue of which Feelings otherwise quite unlike, range themselves together either under the head of pleasurable or under the head of painful. Just as we saw that the division of Feelings into real and ideal, which is based on a functional difference, cuts across the divisions into central, ento-peripheral, and epi-peripheral, which are based on structural differences; so here we may see that the division of Feelings into agreeable and disagreeable, traverses all other lines of demarkation—groups into one heterogeneous assemblage sensations from all parts and emotions of various kinds, together with the ideas of such sensations and emotions, and into another assemblage sensations and emotions, real and ideal, similarly heterogeneous.

To treat fully of consciousness under this further aspect, would carry us still more widely out of our course; for the phenomena of Pleasure and Pain are perhaps the most obscure and involved which Psychology includes. It must suffice to set down here what appear to be the essentials.

§ 123. Pleasures and Pains are concomitants of certain states, local or general—certain actions, I was about to say, but since pains of one class accompany what we distinguish as inactions (though these can never be absolute while the life, general or local, continues) it is better to use the word states. Not that all living states, either of the whole organism or of any organ, are accompanied by pleasures or pains; for many of them, as those of the viscera during the normal discharge of their functions, yield to consciousness no feelings of any kind; and there are also feelings yielded by higher organs that are neither pleasureable nor painful, as an ordinary sensation of touch. But while certain states cause no feelings, and other states cause indifferent feelings, the feelings distinguished as pleasurable and painful manifestly result from states of some kind; and the question is——What are the states which yield Pains and what are the states which yield Pleasures?

As implied by the parenthetical remark just made, there are pains arising from states of inaction—pains we call them, since we here use the word as antithetical to pleasures; but they are best known as discomforts or cravings, from having a quality in which they are like one another and unlike pains commonly so-called. Let us glance at their leading kinds. The cravings due to inaction of the organs yielding the higher epi-peripheral feelings, are rarely strong because these organs are rarely quite inactive. Sensations of touch being incessant, the want of them is never felt. Sounds are so habitually heard everywhere that few experience the desire for them which follows continued silence. Only after being confined for days in the dark does there come a positive longing for light and colour. The absence of odours never becomes an element of discomfort. And though after persistent denial of them certain natural tastes, as those of sweetness, and still more certain acquired tastes, as those of alcohol and tobacco, come to be much desired; yet the cravings for them are by no means so strong as the accompanying ento-peripheral cravings with which they are apt to be confounded. Among cravings of the ento-peripheral order occur some of the strongest. Inaction of the alimentary canal is soon followed by hunger; and if the inaction continues, this, rising presently to a distinct discomfort, eventually passes into something more intense. So, too, that allied inaction due to deficiency of liquid in the ingesta, brings on the longing we call thirst, which also may rise to a great height. And similarly with the abnormal appetites for habitual stimulants. We must not omit the disagreeable state of consciousness caused by muscular inaction. The irritation that accompanies enforced quiescence, often very manifest in children, must be numbered among the ento-peripheral cravings. There remain the dissatisfactions brought on by certain inactions of the central organs of the nervous system—the emotional cravings. Solitude, necessitating quiescence of the faculties exercised in holding converse with our fellow-beings, leads by and by to great misery. The entire absence of marks of approval from those around us, causes a state of consciousness difficult to bear; and persons accustomed to positive applause feel unhappy when it is not given. In like manner, the faculties which have the closer human relations for their sphere, yield their pains of inaction—the yearnings of the affections. To meet an obvious criticism it may be remarked that the intenser forms of distress caused by the breaking of these closer human relations, are not to be included among emotional cravings; but result from the representation of a future in which such cravings will never be satisfied.

We now turn to pains of the opposite kind—the states of consciousness that accompany excessive actions. Of these there are, of course, classes corresponding to the above-described classes of the pains of deficient actions. They must be briefly enumerated. Among the epi-peripheral feelings, those which originate on the general surface are conspicuously capable of being raised to a painful strength. The sensation of heat much intensified passes into the unbearable sensation we know as burning or scalding. Pressure against a hard body produces by its excess an intolerable state of consciousness. Doubtless, too, all smarts and aches caused by bruises, wounds, and other injuries of the surface, imply the undue excitement of nerves which when normally excited yield the normal peripheral feelings. Auditory sensations occasionally rise to an extreme that cannot be borne with equanimity. Persons in the cupola from which a cannon is fired, or those in a belfry when a peal is being rung, have vivid experiences of this. It is not often that visual feelings reach a height which is painful—in men, at least, whose eyes are strong. But men whose eyes are debilitated cannot look at the sun without suffering, and even find it unpleasant to gaze at a large area of bright scarlet. Olfactory feelings, often exceedingly disagreeable, do not become positive pains. Inhaling ammonia does, indeed, cause a kind of smart; but this, arising not in the olfactory chamber so much as in the nostrils, is rather to be classed as an intense form of common sensation. Tastes, too, though many of them are repugnant, do not become painful by increase of strength; nor when the repugnancy exists is strength always a needful condition. On the one hand, such a taste as that of cod-liver oil is disagreeable even though slight; while, on the other hand, sweetness is not rendered disagreeable by any degree of intensity. Among feelings of ento-peripheral origin, the connexion between pain and excess of action is familiar. Such of them as accompany muscular strains show us pains reached through intensification of feelings which when moderate are not painful: the distressing consciousness of extreme effort is a higher degree of the ordinary consciousness of effort. But passing over the ento-peripheral pains of this order, it is to be remarked of the rest that they arise from excessive actions in organs whose normal actions yield no feelings. The pains consequent on repletion come from parts which, when not overtaxed, add no appreciable elements to consciousness; and it is thus with the viscera in general. The like may be said of those pains initiated within the limbs which are not directly due to excesses of action of the limbs themselves or parts of them. Such pains, consequent, let us say, on gout or on a local disease, imply extreme demands made on certain local structures and their nerves, which when not over-worked originate no sensations. The central feelings are scarcely in any case made painful simply by excess. Normal emotions responding to the various normal activities, do not, however high they may rise, become intrinsically disagreeable. We have, indeed, occasional allusion to states in which "joy is almost pain," showing a perceived approach to this effect of excess; but if pain so caused is ever actually reached, it is very rarely.

Thus recognizing, at the one extreme, the negative pains of inactions, called cravings, and, at the other extreme, the positive pains of excessive actions, the implication is that pleasures accompany actions lying between these extremes. It is true that the positive or negative pain attending one or other of the extremes is missing among actions of certain orders; and that other actions may be named which are disagreeable even when of medium intensity. In some of these cases the explanation is that no feeling of the order due to the extreme state arises because the extreme state is not reached. The fact that from the kidneys there comes no craving, may pair off with the fact that they have always work to do. No one longs for tactual impressions for the sufficient reason that tactual impressions are unceasing. The emotions that go along with the successful pursuit of the various objects of life, cannot well rise from a pleasurable degree to a painful degree; since the environing conditions which cause them do not admit of the required progressive intensification. Generally speaking, then, pleasures are the concomitants of medium activities, where the activities are of kinds liable to be in excess or in defect; and where they are of kinds not liable to be excessive, pleasure increases as the activity increases, except where the activity is either constant or involuntary.

Though we thus see whereabouts pleasure is to be found among the feelings, it must be admitted that its relations remain but ill-defined. The conception of it as the concomitant of an activity which is neither too small nor too great, is a conception open to a criticism akin to that made by Mr. Mill on the doctrine of Sir W. Hamilton, that "pleasure is a reflex of the spontaneous and unimpeded exertion of a power, of whose energy we are conscious," and upon the kindred doctrine of Aristotle, that it accompanies the action of a healthy faculty on its appropriate object. For there arise the questions——What constitutes a medium activity? What determines that lower limit of pleasurable action below which there is craving, and that higher limit of pleasurable action above which there is pain?

Is it possible to answer these questions, and is it possible to answer the further question—How happen there to be certain feelings (as among tastes and odours) which are disagreeable in all degrees of intensity, and others that are agreeable in all degrees of intensity? Answers are, I believe, to be found. But they must be sought in a region which psychologists have not explored. If we study feelings only as they at present exist, we shall find no solution; but we may find a solution if we turn to the past conditions under which feelings have been evolved.

§ 124. Let us first glance at the fact, sufficiently obvious and sufficiently significant, that the extreme states, positive and negative, along with which pains occur, are states inconsistent with that due balance of the functions constituting health; whereas that medium state along with which pleasure occurs, is consistent with, or rather is demanded by, this due balance. This we may see *à priori.* In a mutually-dependent set of organs having a *consensus* of functions, the very existence of a special organ having its special function, implies that the absence of its function must cause disturbance of the *consensus*—implies, too, that its function may be raised to an excess which must cause disturbance of the *consensus*—implies, therefore, that maintenance of the *consensus* goes along with a medium degree of its function. The *à priori* inference involved, that these medium actions productive of pleasure must be beneficial, and the extreme actions productive of pain detrimental, is abundantly confirmed *à posteriori* where the actions are of all-essential kinds. Here are a few cases.

Intense cold and intense heat both cause acute suffering, and if the body is long exposed to them both cause death; while a moderate warmth is pleasurable and conduces to physical well-being. Extreme craving for food accompanies a hurtful inaction of the digestive organs, and if this craving and this inaction persist the result is fatal. Conversely, if solid food, or liquid, continues to be swallowed under compulsion, regardless of the painful sensations produced, the effect is also detrimental, and may even kill. But between these pains attending deficient and excessive action there are the pleasures of eating, which are keenest when the benefit to be derived is greatest. To a person in health duly rested, the feeling that accompanies absolute inaction of the muscles is unbearable; and this inaction is injurious. On the other hand, extreme exertion of the muscles in general is alike distressing and productive of prostration, while exertion of a particular muscle pushed to a painful excess, leaves a temporary paralysis, and occasionally, by rupturing some of the muscular fibres, entails prolonged uselessness. Arrest of breathing by forcible closure of the air-passages, causes an intolerable state of consciousness; and life soon ceases if there is no relief. The breathing of foul air is injurious as well as repugnant; while the breathing of air that is exceptionally fresh and pure, is both pleasurable and physically advantageous. So, too, is it with the feelings caused by contacts with objects. Though, as above pointed out, we cannot be debarred from these, and therefore have no craving for them and little or no pleasure in them, yet we are liable to excesses of them and the accompanying pains; and these pains are the correlatives of detrimental results—crushings, and bruises, and lacerations. It is even so with extremely strong tastes and smells. The intense vegetal bitters are poisonous in any considerable quantities, and the intensest are poisonous in very small quantities. Powerful acids, too, are poisonous—being, indeed, immediately destructive of the membranes they touch. And gases that violently irritate when inhaled, as concentrated ammonia, or as pure chlorine, or as hydrochloric acid, work deleterious effects.

These facts should of themselves suffice to produce the conviction, spite of apparent exceptions, that pains are the correlatives of actions injurious to the organism, while pleasures are the correlatives of actions conducive to its welfare. We need not, however, rest satisfied with an induction from these instances yielded by the essential vital functions; for it is an inevitable deduction from the hypothesis of Evolution, that races of sentient creatures could have come into existence under no other conditions.

§ 125. If we substitute for the word Pleasure the equivalent phrase—a feeling which we seek to bring into consciousness and retain there, and if we substitute for the word Pain the equivalent phrase—a feeling which we seek to get out of consciousness and to keep out; we see at once that, if the states of consciousness which a creature endeavours to maintain are the correlatives of injurious actions, and if the states of consciousness which it endeavours to expel are the correlatives of beneficial actions, it must quickly disappear through persistence in the injurious and avoidance of the beneficial. In other words, those races of beings only can have survived in which, on the average, agreeable or desired feelings went along with activities conducive to the maintenance of life, while disagreeable and habitually-avoided feelings went along with activities directly or indirectly destructive of life; and there must ever have been, other things equal, the most numerous and long-continued survivals among races in which these adjustments of feelings to actions were the best, tending ever to bring about perfect adjustment.

If we except the human race and some of the highest allied races, in which foresight of distant consequences introduces a complicating element, it is undeniable that every animal habitually persists in each act which gives pleasure, so long as it is does so, and desists from each act which gives pain. It is manifest that, for creatures of low intelligence, unable to trace involved sequences of effects, there can be no other guidance. It is manifest that in proportion as this guidance approaches completeness, the life will be long; and that the life will be short in proportion as it falls short of completeness. Whence it follows that as, other things equal, the longer-lived individuals of any species will more frequently produce and rear progeny than the shorter-lived, the descendants of the one must tend to replace those of the other—a process which, equally operative among the multiplying families of these surviving descendants, cannot but work towards maintenance and improvement of the guidance.

How then, it will be asked, does it happen that animals sometimes die from eating poisonous plants, or surfeit themselves fatally with kinds of food which, though wholesome in moderate quantities, are injurious in large quantities? The reply is that, by natural selection, the guidance of pleasures and pains can be adjusted only to the circumstances of the habitat within which the special type has been evolved. Survival of the fittest cannot bring the inclinations and aversions into harmony with unfelt conditions. And since each species under pressure of increasing numbers is ever thrusting itself into adjacent environments, its members must from time to time meet with plants, with prey, with enemies, with physical actions, of which neither they nor their ancestors have had experience, and to which their feelings are unadapted. Not only by migration into other habitats, but also by changes, inorganic and organic, within its own habitat, does each species suffer from failures of adjustment. But mis-adjustment inevitably sets up re-adjustment. Those individuals in whom the likes and dislikes happen to be most out of harmony with the new circumstances, are the first to disappear. And if the race continues to exist there cannot but arise, by perpetual killing-off of the least adapted, a variety having feelings that serve as incentives and deterrents in the modified way required.

We will consider more at length, in connection with our own race, the qualifications with which the general law must be received.

§ 126. Mankind shows us in many conspicuous ways, the failures of adjustment that follow changes of environing conditions—not so much the changes which migrations involve, though these too are to be taken into account, but the changes caused by the growth of large societies.

Pre-historic men, like men as we find them still in many parts of the Earth, had feelings congruous with the wandering predatory life, only incipiently social, which they had to lead. Inadequate supply of wild food compelled some of their descendants to become pastoral and agricultural; and these multiplied into populous tribes and eventually into settled communities. They were thereby cut off from activities like those of the men whose characters they inherited, and were forced into activities to which their inherited characters furnished no incentives. Throughout the course of civilization this has been, and continues in large measure to be, the source of discordances between inclinations and requirements. On the one hand, there still survive those feelings, quite proper to our remote ancestors, which find their gratification in the destructive activities of the chase and in warfare—feelings which, anti-social as is the conduct they prompt, indirectly cause numerous miseries. On the other hand, persistent and monotonous labour has been rendered by the pressure of population a necessity; and though to civilized men work is by no means so repugnant as to savages, and to a few is even a source of pleasure, yet the re-adjustment has at present gone by no means so far that pleasure is habitually found in the amount of work habitually required. Further, it is to be observed that many of the industrial activities which the struggle for existence has thrust on the members of modern societies, are in-door activities—activities not only unresponded to by the feelings inherited from aboriginal men, but in direct conflict with those more remotely inherited and deeply organized feelings which prompt a varied life in the open air.

Secondary discordances, and resulting derangements of the normal guidance, are indirectly caused by this enforced persistence in habits of life at variance with the needs of the constitution. A sedentary occupation pursued for years in a confined air, regardless of protesting sensations, brings about a degenerate physical state in which the inherited feelings are greatly out of harmony with the superinduced requirements of the body. Desired foods, originally appropriate, become indigestible. An air pleasure-giving by its freshness to those in vigour, brings colds and rheumatisms. Amounts of exertion and excitement naturally healthful and gratifying, are found injurious. All which evils, due though they are to continued disregard of the guidance of inherited feelings, come eventually to be mistaken for proofs that the guidance of inherited feelings is worthless.

There is yet another derivative cause of derangement. Men whose circumstances compel them day after day to call certain powers into undue and painful action, while they are shut out from most of the pleasures accompanying the due action of other powers, are liable to carry too far such pleasurable actions as remain to them. After disagreeable states of consciousness long submitted to, an agreeable state of consciousness is received with eagerness; and in the absence of alternative agreeable states is maintained by too great a persistence in the action which brings it. Hence arise various kinds of excess. Feelings which would not have misled men if all their other feelings had had appropriate spheres of action, become misleading when these other feelings are repressed. And then there is charged upon the active feelings that misguidance which has arisen from enforced disobedience to the rest.

The rectification of these profound and multitudinous discordances by the re-equilibration of constitution and conditions, proceeds in the human race very slowly, for several reasons. They are these. As pointed out in the *Principles of Biology*, § 166, the fitting of an organism to new circumstances becomes less and less easily effected by survival of the fittest in proportion as the organism becomes complex. This is illustrated most clearly among ourselves. There are so many kinds of superiorities which severally enable men to survive, notwithstanding accompanying inferiorities, that natural selection cannot by itself rectify any particular unfitness: especially if, as usually happens, there are co-existing unfitnesses which all vary independently. Indirect equilibration can play but a secondary part, and the change having to be wrought by direct equilibration, or the inheritance of functionally-produced alterations, is slower than it would otherwise be. Again, the conditions to which we must be re-adapted are themselves changing. Each further modification of human nature makes possible a further social modification. The environment alters along with alteration of the constitution. Hence there is required re-adjustment upon re-adjustment. Once more, such help to re-adjustment as would result from survival of the fittest if individuals in most respects ill-fitted were allowed to disappear, is in great part prevented. Indeed, the imbecile and idle are artificially enabled to multiply at the expense of the capable and industrious.

In the case of mankind, then, there has arisen, and must long continue, a deep and involved derangement of the natural connexions between pleasures and beneficial actions and between pains and detrimental actions—a derangement which so obscures these natural connexions that even the reverse connexions are supposed to obtain. And the half-avowed belief, very commonly to be met with, that painful actions are beneficial and pleasurable actions detrimental, has been, and still is, upheld by creeds which present for the worship of men a Being who is supposed to be displeased with them if they seek gratifications, and to be propitiated by gratuitous self-denials and even by self-tortures.

§ 127. Here, however, we accept the inevitable corollary from the general doctrine of Evolution, that pleasures are the incentives to life-supporting acts and pains the deterrents from life-destroying acts. Not only do we see that among inferior sentient creatures this guidance is undeniably efficient, but also that it is undeniably efficient in ourselves, so far as regards the functions on which life immediately depends. And we cannot here suppose that a regulative system efficient for all-essential actions has to be reversed for the actions growing out of them.

One more qualification has to be made. We are apt to take for granted that the beneficial actions secured must be actions beneficial to the individual; whereas the only necessity is that they shall be beneficial to the race. The two are by no means identical. Up to a certain point, while the individual is young and not yet fertile, its welfare and the welfare of the race go together; but when the reproductive age is reached, the welfare of the individual and of the race cease to be the same, and may be diametrically opposed. In fact they are diametrically opposed more frequently than not. I do not refer merely to those cases of asexual genesis prevalent among the lower types of animals, in which, by the breaking up of its body into two or more, the individuality of the parent is lost in the individualities of the offspring; but I refer to those cases of sexual genesis, very general among invertebrate animals, in which the death of the parents is a normal result of propagation. In the great class Insects, the species of which out-number all other animal species, the rule is that the male lives only until a new generation has been begotten, and that the female dies as soon as the eggs are deposited, or, as in some cases, leaves the dead shell of her body to be a protecting cover to the eggs. Here, however, each new generation does not depend for its welfare on continued life of the old. Where, as among the higher animals, the offspring have to be fostered, survival of the fittest must establish such a constitutional balance that obedience to the feelings, peripheral and central, which secure the maintenance of the species cannot be fatal or even seriously injurious. And where, as in the highest types, successive broods or successive individuals are produced during a series of years, and especially where the successive individuals so produced have to be fostered for long periods, the implied satisfaction of the feelings must be consistent with parental welfare. If we cannot infer, as a necessary result of survival of the fittest, that the guidance of the feelings is here beneficial to the individual, we can at any rate infer that it is not detrimental.

Thus, considering as transitional those many anomalies that accompany the adaptation of the human race to social conditions, and taking account of the qualification just made, we conclude that, up to the reproductive age, pains are the concomitants of actions injurious both to the individual and to the species, while pleasures are the concomitants of actions beneficial both to the individual and to the species; and that while, after reproduction commences, the same relations continue to hold, the additional relations between feelings and actions which then arise, may be of a reverse kind, but that the reversal cannot obtain among the higher types of sentient beings.

§ 128. A few words must be added on one further question—What are the intrinsic natures of Pleasures and Pains, psychologically considered? This question appears unanswerable, and may eventually prove to be so. Without here attempting to answer it, I will briefly set down three allied general facts which indicate the direction in which an answer is to be found, if there is one.

Pleasures to a large extent, and Pains to some extent, are separate from, and additional to, the feelings with which we habitually identify them. If I hear a sound of beautiful quality, an agreeable state of consciousness is produced; but if this sound is unceasing, or perpetually repeated, the state of consciousness loses its agreeableness without otherwise changing. A glow of delight accompanies the sight of a fine colour; but after having the colour before the eyes for a long time there remains only the consciousness of its quality—the delight is gone. Similarly, if I go on tasting something sweet, there comes a time when the gratification ends, though the sense of sweetness continues. Doubtless the sense of sweetness itself eventually becomes deadened; but the gratification gives place to nausea before this happens. Among Pains the parallel fact is less conspicuous; but it is not difficult to perceive that along with the localized pain, say of a bruise or a burn, there goes an element of distress that is not localized.

The second of these allied truths, illustrations of which serve in part to re-illustrate the first, is that Pleasures and Pains may be acquired—may be, as it were, superposed on certain feelings which did not originally yield them. Smokers, snuff-takers, and those who chew tobacco, furnish familiar instances of the way in which long persistence in a sensation not originally pleasurable, makes it pleasurable—the sensation itself remaining unchanged. The like happens with various foods and drinks, which, at first distasteful, are afterwards greatly relished if frequently taken. Common sayings about the effects of habit imply recognition of this truth as holding with feelings of other orders. That acute pain can be superinduced on feelings originally agreeable or indifferent, we have no proof. But we have proof that the state of consciousness called disgust may be made inseparable from a feeling that was once pleasurable. The extreme repugnances shown by children to the sweet things given them along with medicines, are illustrations; and probably nearly every one can furnish from his own experience some instance of acquired aversion of another order.

The third of these allied facts is that Pleasures are more like one another than are the feelings which yield them, and that among Pains we may trace a parallel resemblance. The wave of delight produced by the sight of a grand landscape, is qualitatively much the same as that produced by an expressive musical cadence. There is close kinship between the agreeable feelings aroused, the one by a kind word and the other by a highly poetical thought. Nay, it needs but to mark the accompanying expression of face, to perceive that even the pleasure which an exquisite perfume yields is to a considerable extent of the same nature. Indeed, the frequent application of the words sweet, delicious, &c., to things and acts of all kinds that yield great pleasure, shows that this similarity is habitually recognized. Pains display this kinship still more conspicuously. Though the ordinary feelings of heat, of pressure, and of muscular tension, resemble one another but little, yet when they are severally raised to high intensities the resulting pains are nearly allied. Indeed, there is an obvious family likeness among all the peripheral pains when intense, and among all the central pains when intense.

These three general facts taken together, warrant the suspicion that while Pleasures and Pains are partly constituted of those local and conspicuous elements of feeling directly aroused by special stimuli, they are largely, if not mainly, composed of secondary elements of feeling aroused indirectly by diffused stimulation of the nervous system. In a future part of this work we may find further reasons for believing this.

PART III.

GENERAL SYNTHESIS.

CHAPTER I.

LIFE AND MIND AS CORRESPONDENCE.*

§ 129. Having in the first part of this work contemplated those facts of nervous structure and function which form the data of Psychology; and having, in the part just closed, grouped together the inductions drawn from a general survey of mental states and processes; we are prepared for a deductive interpretation. The field of inquiry which we incidentally entered in the last chapter, when seeking an explanation of the phenomena of pleasure and pain, we have now to explore systematically throughout its whole extent.

If the doctrine of Evolution is true, the inevitable implication is that Mind can be understood only by observing how Mind is evolved. If creatures of the most elevated kinds have reached those highly integrated, very definite, and extremely heterogeneous organizations they possess, through modifications upon modifications accumulated during an immeasurable past—if the developed nervous

* This Chapter stands in place of five chapters which, in the original edition of this work, prepared the way for the General Synthesis. The first of them, on Method, I hope eventually to include in an introduction to *First Principles.* The others are now embodied in Part I. of the *Principles of Biology.* Except by the omission of these introductory chapters, the General Synthesis remains in substance unchanged; but it has been much improved in expression.

systems of such creatures have gained their complex structures and functions little by little; then, necessarily, the involved forms of consciousness which are the correlatives of these complex structures and functions must have arisen by degrees. And as it is impossible truly to comprehend the organization of the body in general, or of the nervous system in particular, without tracing its successive stages of complication; so it must be impossible to comprehend mental organization without similarly tracing its stages.

Here, then, we commence the study of Mind as objectively manifested in its ascending gradations through the various types of sentient beings.

§ 130. From what point are we likely to obtain the widest view of this evolution? How shall we guide ourselves towards a conception general enough to include the entire range of mental manifestations, up from creatures that yield but the faintest traces of feeling to creatures having intellects and emotions like our own?

In pursuance of the method of choosing hypotheses, we must compare mental phenomena with the phenomena most like them, and observe what character, presented by no other phenomena, they both present.* A generalization uniting two different but allied classes of facts, necessarily unites all the facts contained in either class. Hence, if we find a formula which along with mental evolution includes the evolution nearest akin to it, we shall, by implication, find a formula comprehending the entire process of mental evolution. It may afterwards be needful so to limit this formula that mental evolution alone is expressed by it. But we shall best fulfil the requirements of clear exposition by first exhibiting mental evolution as it may be most gene-

* Reference is here made to the omitted chapter on Method, named in the preceding note.

rally conceived, and subsequently specializing the conception.

The phenomena which those of Mind resemble in the greatest degree are those of bodily life. While these classes of phenomena are intimately related to one another, they are related to other classes of phenomena in comparatively remote ways. Our question, therefore, becomes—What is it that mental life and bodily life have in common? And this amounts to the question—What distinguishes Life in general?

§ 131. Thus, in looking for a conception of mental evolution sufficiently large to take in all the facts, we are led back to the definition of Life reached at the outset of the *Principles of Biology.*

In Part I., Chap. IV. of that work, the proximate idea we arrived at was that Life is "the definite combination of heterogeneous changes, both simultaneous and successive." In the next chapter it was shown that to develop this proximate idea into a complete idea, it is needful to recognize the connexion between these actions going on within an organism and the actions going on without it. We saw that Life is adequately conceived only when we think of it as "the definite combination of heterogeneous changes, both simultaneous and successive, in correspondence with external co-existences and sequences." Afterwards this definition was found to be reducible to the briefer definition—"The continuous adjustment of internal relations to external relations;" and though, by leaving out the characteristic of heterogeneity, this definition is rendered somewhat too wide, so that it includes a few non-vital phenomena which simulate vitality, yet practically no error is likely to result from its use.

That Life consists in the maintenance of inner actions corresponding with outer actions, was confirmed on further observing how the degree of Life varies as the degree of correspondence. It was pointed out that, beginning with the low life of plants and of rudimentary animals, the progress to life of higher and higher kinds essentially consists in a continual improvement of the adaptation between organic processes and processes which environ the organism. We observed how along with complexity of organization there goes an increase in the number, in the range, in the speciality, in the complexity, of the adjustments of inner relations to outer relations. And in tracing up the increase we found ourselves passing without break from the phenomena of bodily life to the phenomena of mental life.

We have now to start afresh, and to develop the general truth there briefly indicated into a combination of more special truths.

§ 132. In doing this it will be needful to begin with the life of forms almost too simple to be called organisms, that we may note the first traces of differentiation between the vital actions we class as physical and the vital actions we class as psychical. Though throughout we shall continue to regard these two classes of actions as falling within the one class marked out by our definition, yet, as we follow under each of its several aspects the progress of the correspondence between the organism and its environment, the reader will not fail to observe how we pass from the physical to the psychical the moment we rise above the correspondences that are few, simple, and immediate.

CHAPTER II.

THE CORRESPONDENCE AS DIRECT AND HOMOGENEOUS.

§ 133. The lowest life is found in environments of unusual simplicity. Most environments present both co-existences and sequences; but there are some which, for a short time, present co-existences only; and in these, during this short time, occur the least developed organic forms. Of those classed with the vegetal kingdom, may be instanced the Yeast-plant, and the *Protococcus nivalis* or red snow alga. Of those held to be of animal nature, the *Gregarina* and the Hydatid may be taken as samples.

The life of each of these organisms consists, almost wholly, of a few contemporaneous processes adjusted to the co-existent properties of the medium which surrounds it. The yeast-plant has for its habitat a fluid consisting of water holding in solution certain oxy-hydro-carbons, some nitrogenous matter, oxygen, and probably other elements in minor proportions. That it may flourish, the water must be neither very hot nor very cold; and light must be excluded. The conditions being fulfilled, the yeast-plant displays what we call vital changes, in correspondence with chemical changes among the substances bathing its surface. The cell grows and multiplies; the fluid ferments; and while the fluid continues to supply the needful materials under the needful conditions, the cell continues to manifest the same phenomena. But let the temperature be considerably raised, or some of the ingredients exhausted, and the actions cease. The life, limited in length to the brief period during which the environment remains practically uniform, exhibits no successive changes such as those by which a shrub responds to the alternations of day and night, and of the seasons. Excluding those modifications of form and size which are the necessary concomitants of continued assimilation, the only successive changes exhibited by the yeast-plant in common with the higher plants, are those which end in the formation of spores. Determined as they probably are by the diminishing quantities of the materials needful for growth, these generative actions may be regarded as successive changes in the organism corresponding with successive changes in the environment; and most likely there is no organism but what, in addition to the simultaneous processes taking place in it, undergoes a serial process of this character. Evidently, however, the two orders of changes, answering in this case to the two all-essential functions of assimilation and reproduction, exist under their simplest forms in correspondence with the simplest relations in the environment; and ending as they do with that new state of the environment soon arising, the life is as short as it is incomplex.

It is needless to present in detail each of the other cases named. The *Protococcus nivalis* exists in snow—a medium simple and constant in chemical character, and restricted in its variations of temperature. Reddening by its rapid multiplication large tracts in the arctic regions in a single night, during which the circumstances must remain almost uniform, this minute organism exhibits vital processes corresponding only to surrounding co-existences; and can undergo scarcely any changes corresponding to surrounding sequences. To a new state in its medium, it does not adapt itself but dies: the snow melts and it disappears. Similarly with the *Gregarina*—a single-celled creature which inhabits the intestines of certain insects; which is there bathed by nutritive liquid; which is kept at a tolerably constant temperature; and which exists no longer than its special environment exists. In these and other such cases the peculiarities to be noted are:—first, that the actions in the organism are immediately dependent on the affinities of the elements touching it on all sides; and, second, that the internal changes proceed uniformly, or nearly so, because, during the brief time that the life lasts, the external relations remain uniform, or nearly so. The correspondence is at once *direct* and *homogeneous*. The disintegrating matter and the matter to be integrated, being everywhere diffused through the environment, it results that all the agents to which the vital changes stand related, are not only in *contact* with the organism, but *continually* in contact with it. And hence there need neither those motions nor locomotions, which, where they occur, involve more or less heterogeneity in the correspondence.

§ 134. In strictness, no other forms of life than those conditioned as above described, can be said to exhibit a correspondence at once direct and homogeneous. But the transition to higher forms being gradual, it is impossible to make divisions in such way as entirely to avoid incongruities; and on the whole, it seems best to notice here a class of organisms which, while they exhibit motion, either absolute or relative, do so with comparative uniformity. The simplest of the ciliated animalcules; the most regular of the compound ciliated organisms, like the *Volvox globator;* together with the Sponges and their allies; may be instanced as displaying life of this order.

Water, either fresh or salt, being in all these cases the medium inhabited, the general fact to be observed is, that the incipient multiformity of the vital actions is in correspondence with the incipient multiformity of the environment. Though, from a human point of view, the liquids in which the yeast-plant and the *Gregarina* live are far more heterogeneous than the water, either of the sea or of a pond; yet, relatively to these contained organisms, they are less heterogeneous. For every portion of the wort bathing the cell-wall of the yeast-plant, and every portion of the nutritive emulsion surrounding the *Gregarina*, presents the matter to be assimilated; but every portion of the water in which a *Protozoon* swims, though it presents oxygen, does not present nutriment. Evenly diffused as the food of the first is, and irregularly scattered as is that of the last, the external relations must be more homogeneous to the one than to the other. And manifestly, an organism whose medium, though unceasingly disintegrating it, is not unceasingly supplying it with integrable matter, but presents only dispersed atoms of integrable matter, must either traverse its medium with such velocity as shall bring it in contact with the requisite quantity of integrable matter, or must cause the medium to move past it with such velocity—must have either an absolute motion, as the infusory animalcule, or a relative motion, as the sponge towards the water it draws in and expels. Thus then, the addition of mechanical changes to the changes displayed by motionless organisms, is the addition of new internal relations in correspondence with new external relations.

It is, however, to be remarked, that the processes by which movements of this order are effected, are themselves in direct and nearly homogeneous correspondence with almost ever-present properties of the environment. The fact that the ciliary action of fresh-water creatures ceases when they are put into sea-water, and that of sea-water creatures when they are put into fresh-water; the fact that when creatures displaying it have been killed, the ciliary action on uninjured parts, and even on parts that have been cut off, continues for a long time; and the further fact, discovered by Virchow, that ciliary motion which has ceased may be re-excited by a solution of caustic potash; unite to show that the motion of these microscopic hairs is caused by the immediate contact of something in the environment—consists of a succession of minute internal changes, in correspondence with those minute recurring actions of the medium which the waving of the cilia themselves involve. And the occasional suspensions of the motion may possibly result from local deficiencies in the medium, of those materials or conditions that determine it; in which case this slight heterogeneity in the mechanical changes answers to a slight heterogeneity in the environment.

CHAPTER III.

THE CORRESPONDENCE AS DIRECT BUT HETEROGENEOUS.

§ 135. The advance, of which we have just marked the first steps, from a correspondence that is uniform to one that is varied, begins to show itself distinctly when there occur either absolute or relative changes in the environment. Among plants, it is seen when, from a habitat in which the needful elements, bathing the organism on all sides, are ever presented under fit conditions for absorption by it, we pass to a habitat in which the needful elements, though always around, are not always presented under fit conditions for absorption. And among animals, it is seen both on passing from the *Protozoa* to the higher aquatic creatures, which being larger and therefore needing larger prey are in the condition of having their nutriment less uniformly diffused, and on passing from aquatic creatures to terrestrial ones, to which the less uniform diffusion of nutriment is not relative only, but absolute. The result is, that besides correspondence with a few ever-present co-existences in the environment, we have now correspondence with a few sequences in it. Let us glance at each class of cases.

§ 136. The higher plants, requiring not only carbonic acid diluted with air, but light, a certain temperature, a certain soil, and a certain quantity of moisture, show us variations in the vital actions corresponding with variations which the environment undergoes in respect to these conditions—variations answering to those of the hour, the weather, and the seasons. As we lately saw, the lowest life continues only so long as its environment remains practically homogeneous, both in Space and Time. Life a degree higher must be looked for in organisms displaying changes that correspond with the *most general* changes to which the environment is liable; and this is the kind of life exhibited by the vegetal kingdom at large. These changes in light and heat, are most general both as occurring with greater regularity in time and amount than any others, and as affecting the whole mass of the surrounding medium. Being periodic and universal, as well as comparatively slow, they produce only that small degree of heterogeneity in the environment, answered to by the small degree of heterogeneity in the visible changes of plant-life.

It should be added that the greater complexity of correspondences, and therefore greater length in the series of correspondences, which these higher plants display, involves a further group of vital processes. The long-continued growth made possible by the better adjustment of internal relations to external relatious, implying, as it does, an increasing remoteness in the parts of the organism from one another, supposes some means of putting the remote parts in communication; and hence a circulatory system. Or, more strictly, it may be said, that a circulatory system is necessitated by increase of size, joined with the division of the environment into the two halves, soil and air, so that the only respect in which the plant shows us habitual movements (those of sap) answers to the only respect in which the elements in its environment are not co-extensive in Space.

§ 137. Turning from plants to plant-animals or zoophytes, we see that while in them there are general successive changes corresponding, like those of plants, with general successive changes in their environment, they exhibit certain special changes, corresponding with special changes in it. Though to the chemical, thermal, and hygrometric actions affecting the whole mass of its medium, the actions going on in the plant slowly respond, they do not respond to surrounding mechanical actions; as those of a wire-worm gnawing its roots, or a herbivore browsing on its leaves. But the most conspicuous of a zoophyte's actions are those which follow the touching of its expanded tentacles. To a relation of co-existence between tangible and other properties, presented in a particular part of the environment, there corresponds, in the organism, a relation of sequence between certain tactual impressions and certain contractions. Here are several facts to be noticed. First, that being a stationary creature whose medium does not supply matter to be integrated so uniformly as it supplies disintegrating matter, the zoophyte must obtain matter to be integrated by arresting those portions here and there moving through its medium; and doing this presupposes sensitiveness and contractility connected in the manner seen. Second, that the ability to respond, not simply to the co-existences and sequences presented by the whole mass of the environment, but to the co-existences and sequences presented by particular bodies in it, is an advance in the correspondence; which is also rendered more heterogeneous by the addition.

§ 138. Of all these cases however, as of those in the last chapter, it is to be remarked, that the correspondence between internal and external relations extends only to external relations which have one or both terms in contact with the organism. The processes going on in the yeast-plant cease unless its cell-wall is bathed by the saccharine and other matters on whose affinities they depend. The tree must have its carbonic acid, water, earthy salts, ammonia, and the rest, applied directly to its surface in the presence of light and heat: until they are thus applied it remains inert. And so too among the lowest animals, the substances to be assimilated must come in collision with the organism before any correspondence between inner and outer changes is shown. Alike in those forms of life whose environments perpetually present the disintegrating and integrable matters under the requisite conditions; in those whose environments perpetually present them, but under variable conditions; in those whose environments, though not full of integrable matter, yet contain it in such abundance that mere random locomotion brings them in contact with a sufficiency; and in those whose environments contain it in moving masses so numerous that, though themselves stationary, chance brings them as many as they want —alike in all these forms of life, there is an absence of that correspondence between internal relations and *distant* external relations, which characterizes more highly-endowed forms.

CHAPTER IV.

THE CORRESPONDENCE AS EXTENDING IN SPACE.

§ 139. On ascending from the lowest types of life, in which the adjustment of inner relations to outer relations is thus limited, one marked manifestation of the heightening correspondence, is the increasing distance at which co-existences and sequences in the environment produce adapted changes in the organism. This progress accompanies the development of the senses of smell, sight, hearing, &c., and the subsequent development of the intellect.

There is reason to believe that the susceptibilities to odours, colours, and sounds, arise by degrees out of that irritability which animal tissue, in its lowest forms, possesses. The saying of Democritus that all the senses are modifications of touch, modern science goes far to confirm. Smelling obviously implies the *contact* of dispersed particles with a specially-modified part of the organism—implies that these particles are so carried by a current of air or water as to impinge on this modified part. Hearing results when we feel the vibrations of the air lying in *contact* with our bodies. As the skin at large is sensitive to a succession of mechanical impulses given by dense matter; so certain external auditory structures, easily moved, are sensitive to a far more rapid succession of mechanical impulses given by matter of great tenuity. The organ of sight, again, is one through which the pulses or undulations of a yet more delicate medium are impressed on us—undulations incomparably faster in a medium incomparably rarer. Here however, as before, *contact* of the undulating medium with an adapted part of the surface, is the pre-requisite. So that in every case the sensation produced in us by something in the environment, involves mechanical action on some part of our periphery. In every case, therefore, touch, of a coarse or refined order, is implied. Not only do the conclusions of physicists support this doctrine which Democritus taught; but the conclusions of biologists do the like. The organs of the special senses are every one of them developed from the dermal system—are modifications of that same tissue in which the tactual sense in general is seated. Nor is this all. It is a remarkable fact that the eye and the ear are, in their types of structure, morphologically identical with the *vibrissæ*, or most perfect organs of touch. (*Principles of Biology*, § 295.)

The hypothesis of Evolution implies that the senses in general have a yet deeper basis in those primordial properties of organic matter which distinguish it from inorganic matter. And many facts point to the conclusion that sensibility of all kinds takes its rise out of those fundamental processes of nutrition and waste—integration and disintegration—in which Life, in its primitive form, consists. Though these facts do not suffice to establish such a conclusion, and though it is not necessary to the general argument that they should be here given, yet they form so appropriate an introduction to the subject of the chapter that it will be well to devote a section to them.

§ 140. In the lowest animals, which are so little organized as to be almost, if not quite, homogeneous, all the vital functions are diffused throughout the whole body. Every part exhibits more or less of that contractility which in higher creatures is confined to the muscles; that sensitiveness which they show only in the nerves; that ability to absorb nutriment which is eventually confined to the alimentary canal; that excretory action afterwards divided among the lungs, skin, and kidneys; that reproductive power which with them is localized. Where, as in the lowest creatures of all, the body consists of nothing more than a structureless substance, and where, as in somewhat higher and larger creatures, the body is little else than an aggregation of like units of nucleated protoplasm, there is an almost complete community of functions throughout; and only as fast as this originally-uniform tissue becomes differentiated, does each part lose the power of subserving other processes than its habitual one. (*Principles of Biology*, §§ 57—60.)

But this specialization of functions does not altogether obliterate the original community of functions. Even where "the physiological division of labour" has been carried furthest, many of the tissues retain certain powers of fulfilling one another's duties. In man, skin can discharge the office of mucous membrane, and mucous membrane of skin. Lungs and kidneys can to some extent supply each other's shortcomings. When the liver fails, biliary matter is got rid of through both skin and kidneys. In salivation, the glands of the mouth become supplementary excreting organs. And the skin, while having mainly the function of ejecting perspirable matter, yet remains, to some extent, both a respiratory surface and a surface through which nutriment can be absorbed.

Bearing in mind this general fact, that throughout the life made up of unintelligent organic processes, heterogeneity of function arises out of a primordial homogeneity, the traces of which are never entirely lost, we shall be prepared for a parallelism of method and results in the evolution of that other division of life consisting of the sensory and motor actions. Here, too, we may look for a certain community of function throughout the whole organism—a possession by the whole organism of those susceptibilities which are ultimately located and developed in eyes, ears, nose, and the rest. The nucleated protoplasm which, by one process of differentiation and integration, gives origin to the internal and external systems—the visceral and nervo-muscular organs—must have, to some extent, the powers of the last as well as those of the first. Not only the fundamental division into vegetative and animal functions, but the subdivisions of each of these, must be regarded as specializations of the various properties which every part of the elemental tissue possesses in some slight degree. Let us glance at the genesis of the several senses from this point of view.

Between touch and assimilation there exists, in the lowest creatures, an intimate connexion. In many Rhizopods the tactual surface and the absorbing surface are co-extensive. The *Amœba*, a speck of jelly having no constant form, sends out, in this or that direction, prolongations of its substance. One of these meeting with, and attaching itself to, some relatively fixed object, becomes a temporary limb by which the body of the creature is drawn forward; but if this prolongation meets with some relatively small portion of organic matter, it slowly expands its extremity round this, slowly contracts, and slowly draws the nutritive morsel into the mass of the body, which collapses round it and presently dissolves it. That is to say, the same portion of tissue is at once arm, hand, mouth, and intestine—shows us the tactual and absorbent functions united in one. And if we assume, as we may fairly do, that the behaviour of this protruded part when its end touches assimilable matter, arises from some molecular action set up between the two—is caused by a commencing absorption of the assimilable matter, we shall see a still closer relation between the primordial sense and the primordial vegetative function.

In the same phenomena we may trace a nascent sense of taste. The ability to discriminate between organic and inorganic matter, appears to be possessed in some degree even by the simplest animals. Rhizopods do not absorb indiscriminately all fragments of available size; nor do the tentacles of polypes commonly behave in the same way when touched by inorganic bodies as when touched by organic bodies. And bearing in mind that to creatures living in water, the inorganic or innutritive matters are, generally speaking, the insoluble, while the organic or nutritive are the soluble; it may be inferred that the selective power which they possess is due, as above implied, to the setting up of an assimilative process when assimilable matter is brought in contact with them, and to the absence of that process when the matter presented is not assimilable. So that this selective power, which is an incipient sense of taste, is, primarily, one aspect of that integrating action which mainly constitutes the life. For thus interpreting the facts we have the warrant that, even in its highest developments, tasting forms one link in the chain of assimilative actions. The mouth is part of the alimentary canal, which secretes digestive fluids and takes up dissolved substances. The mouth does both these: its saliva is a digestive fluid, and in the act of tasting, some of the dissolved substances are absorbed through the mucous membrane of the tongue and palate.

Smell has the same root with taste, and remains throughout closely associated with it. In aquatic creatures the two senses can be but degrees of the same: the one responding to a more dilute solution of nutritive substance, and the other to a more concentrated solution. As the soluble matters which surround a fragment of animal tissue are not confined to its actual surface, but are diffused in the surrounding water with an abundance that decreases as the distance increases, it is obvious that a greater susceptibility will render the fragment perceptible before there is absolute contact; and that so, taste must pass gradually into smell. The intimate connection of taste with smell, and of both with touch, is displayed even in man. The nerves of both are spread out under a membrane that is continuous with, and but a slight modification of, the skin; they lie under adjacent parts of this membrane, near its junction with the skin; the sensations they give are so closely allied that, knowing the smell of a substance, we can frequently form an approximately true judgment of its taste; and to both, the substances to be perceived must be presented in solution—the sapid must be either already dissolved, or dissolvable by the saliva, and the odorous must be condensed by the film of moisture covering the membrane which lines the olfactory chambers. Thus, the difference is less between the modes in which the sensations are ultimately produced, than between the forms under which the substances producing them originally exist—liquid or solid in the one case; gaseous or vapous in the other. Further, the relationship of the sense of smell to the fundamental organic actions, is directly traceable even in ourselves. The nostrils and the olfactory chambers which open out of them, are simply divergent branches of the alimentary canal, from which, in the embryo, they are not separate; and absorbing into the system, as they do, some of the floating particles given off by the food that is being eaten, or is about to be eaten, their action, too, is but an evanescent form of nutrition. Add to which, that in so far as the olfactory action is not nutritive it is respiratory; and thus, in a sense, lies between the two primary vital processes.

Again, in its initial stages even the faculty of sight is implicated with the functions of organic life. The organisms which occupy the border land between the animal and vegetal kingdoms, share with plants the ability to decompose carbonic acid under the influence of light. Water containing *Protozoa* gives off oxygen on exposure to the sun's rays. The link between the two great divisions of living forms, which these lowest creatures present in structure, development, and chemical character, they appear to present in their nutritive action also. Naturally, then, we may expect that on passing from them to vegetal and animal organisms respectively, we shall on the one hand find the ability to decompose carbonic acid by the agency of light more and more developed, and on the other hand more and more wanting. Recently disclosed facts answer to the expectation. In the first place, the researches of Schultze go to establish an identity between the chlorophyll of plants, and the colouring matter of sundry low types of animals, as for instance the *Hydra*. In the second place, the *Hydra* habitually shuns the light—habitually chooses the dark side of the vessel in which it is placed. May we not infer that the sensitiveness to light which the *Hydra* exhibits, results from the action of light on its contained chlorophyll; that as in plants, this action is one through which the components of chlorophyll are assimilated; and that thus, the power which the primordial tissue possesses to distinguish light from darkness—a power which forms the germ of the visual faculty—is due to a modification produced by light on the general vital processes? Any doubt that may be felt respecting this hypothesis, will, I think, disappear on remembering that even in ourselves the general surface of the body retains a physiological sensitiveness to light. The darkening of the skin caused by long exposure to sunshine, implies a modified assimilation in the tissue penetrated by light—a change in the absorption of materials supplied by the blood. In transparent and semi-transparent creatures, any such photogenic effect must pervade the whole body; and if so it is easy to understand how light may produce marked changes in such creatures.

That hearing has, like the other senses, a root in the primitive vital functions, there is little if any direct evidence. But for suspecting that it, too, is differentiated from them, we have the reason that to sound, as to light, the whole animal organism in its simplest forms possesses a feeble susceptibility. A slight tap, causing a vibration to pass through the vessel containing them, is responded to by creatures in whom no sign of an auditory organ exists. And if we call to mind the facts that congenitally deaf persons are acutely affected by sonorous vibrations in the bodies they touch, and can perceive such vibrations even in the air when produced by loud concussions, as the firing of cannon—if we infer, as we must, that even in man the whole body is in some degree sensitive to sound, and that the extreme sensitiveness of one part is simply a specialization of this general sensitiveness; we shall have no difficulty in understanding how the humblest zoophytes and molluscoid animals feel the jar of those rapid undulations which constitute objective sound. Of lax tissue, and of like specific gravity with its medium, one of these creatures must be permeated by such undulations throughout its entire mass, almost as though it were so much water; and can scarcely fail to have the substance of its tissues so disturbed as to produce a marked change in their general state, and some consequent change in the external manifestations. Still it may be asked—How do these facts and inferences affiliate the faculty of hearing on the primary vital processes? I reply—They tend to do this by suggesting that the contraction produced by any sonorous vibration permeating a zoophyte's body, results from some modification of these vital processes. The life of one of these creatures is little else than the cumulative result of the lives of its component cells or nucleated portions of protoplasm, which severally absorb the nutrient juices percolating among them, are severally bathed by the oxygenating medium, and severally carry on the integrating and disintegrating actions by and for themselves. Now anything which causes a sudden agitation of the aerating liquid diffused through this almost homogeneous tissue, will produce a sudden increase of vital activity in all the components of the tissue. A rapid succession of undulations propagated through it must do this. And we have but to suppose that the increased vital activity of each component is accompanied by some change, probably isomeric, which alters its form, to understand how a contraction of the entire creature may result.

Thus, there is not a little reason to think that all forms of sensibility to external stimuli, are, in their nascent shapes, nothing but the modifications which those stimuli produce in that duplex process of integration and disintegration which constitutes the primordial life, physiologically considered. A zoophyte cannot be touched without the fluids diffused throughout the disturbed tissues being put in motion, and so made to supply oxygen and nutriment with greater rapidity. Nutritive matter brought in contact with the surface, which is everywhere absorbent, must excite the vital actions still more; and so must cause the touch of nutritive matter to be specially responded to. A diffusion of such matter in the form of an odour, will tend in a slight degree to produce analogous effects. The tissue having the requisite chemical nature, light, also, must modify the assimilative actions. And, as just shown, sonorous vibrations probably do the like. If we make the reasonable assumption that the protoplasm of these almost unorganized creatures is isomerically changed by changes in their vital activity, we have an adequate explanation of the effects which outer agencies produce. So far as they go, facts harmonize with the deduction from the law of organic development—the deduction that as the primitive tissue out of which are evolved the organs of vegetative life, possesses, to some extent, the functional powers of those organs; so must it, to some extent, possess the functional powers of the organs of animal life, and among them of the senses, which similarly arise out of it by a continuous differentiation and integration.

Closing here these speculations respecting the genesis of the several faculties through which the animal organism holds communication with the external world, let us now go on to our immediate subject—that extension of the correspondence in Space, which accompanies the evolution of these faculties.

§ 141. Differentiated gradually, as, in aquatic creatures, smell is from touch and taste, its nascent form is not likely to be detected without careful experiments; and I have not met with accounts of such. "How far any sense of smell exists in the lower invertebrata, cannot be satisfactorily determined," says Dr. Carpenter: "but it would seem not improbable that even where no special organ is apparent, some part of the general surface may be endowed with olfactive sensibility." But however the sense of smell originates, we may conclude that only when in some degree localized, does it become a means whereby internal relations can be brought into something like definite correspondence with external relations which do not occur in contact with the body. Supposing, for argument's sake, that along with its other diffused faculties the whole mass of the primitive animal possesses a feeble susceptibility to odours; the only correspondence which may be established through this, must be seen in some state of readiness to seize the prey, or avoid the enemy, whose proximity an odour implies. Though, by means of such endowment, an inner relation can be adjusted to an outer relation a little removed from the surface; yet, there can be no adjustment to relations either of direction in space or of distance in space. But as soon as there exists a susceptibility that is somewhat localized, the organism must be differently affected by an odoriferous body, according as it is situated in this or that position. And when, as an accompaniment of specialization, there is increased efficiency, a feebly-scented object near to the more highly sensitive tract, may produce a response as great as a strongly-scented object somewhere in its neighbourhood produces in an organism possessed of a diffused but inferior susceptibility.

Passing from these vague beginnings, it will be obvious that as fast as there is developed at the entrance of the respiratory passages a definite apparatus capable of being excited by floating particles, there must be an extension of the space through which co-existences and sequences in the environment can establish corresponding co-existences and sequences in the organism. When we trace up the evolution of the faculty to that perfection in which it is possessed by dogs and by deer, we see that one of the aspects under which the advance presents itself, is the increasing distance at which certain inner and outer relations can be brought into adjustment; and that, other things equal, there is a simultaneous advance in the degree of life.

§ 142. Though that ability to distinguish light from darkness which characterizes the entire body in sundry of the humblest types, foreshadows the visual faculty, nothing like what we call sight results until this ability is concentrated in a particular spot. The rudimentary eye consisting, as in a *Planaria*, of some pigment grains, may be considered as simply a part of the surface more irritable by light than the rest. Some idea of the impression it is fitted to receive may be formed by turning our closed eyes towards the light, and passing the hand backwards and forwards before them. But as soon as even this slight specialization of function is reached, it becomes possible for the organism to respond to the motions of opaque bodies that pass near. While only a general sensitiveness to light exists, the intercepting of the sun's rays by something which throws the whole or a greater part of the creature into shade, is required to produce an internal change; but when there comes to be a specially sensitive spot, anything which casts a shadow on that spot alone, produces an internal change. And as that which obscures only a small part of the organism is usually a comparatively small object, this advance from diffused sensitiveness to concentrated sensitiveness enables the organism to respond, not only to marked general changes in luminousness which its environment undergoes, but also to marked special changes in luminousness caused by the motions of adjacent bodies.

The contrast between light and darkness, or rather between widely different degrees of light, being all that the most rudimentary vision recognizes; and distinct obscuration being producible by an adjacent small object only when it is very close; we may infer that nascent vision extends to those objects alone which are just about to touch the organism, either in consequence of their motion or of its motion. We may infer that it amounts at first to little more than anticipatory touch; and that so there is established in the organism a general relation between visual and tactual impressions, corresponding to the general relation between opacity and solidity in the environment. Be this as it may, however, it is clear that an incipient faculty of sight, though the vaguest imaginable in the sensations it gives, and the most limited that can be conceived in range, implies not only some extension of the correspondence in space, but a new order of correspondence.

As we ascend to creatures having more developed eyes, we find an increase in the sphere of surrounding space throughout which external relations can establish corresponding internal relations. A slight convexity of the epidermic layer lying over the sensitive tract, first serves, by concentrating the rays, to render appreciable less marked variations in the quantity of light; and thus brings into view the same bodies at a greater distance, and smaller or less opaque bodies at the same distance. From this point upwards, through the various types of aquatic creatures to the higher air-breathing creatures, we trace, under various forms and modifications, a complicating visual apparatus and a widening space through which the correspondence extends. It is needless to go into details. Hypotheses and illustrations aside, it is obvious that from the polype which does not stir till touched, up to the telescopic-eyed vulture or the far-sighted Bushman, one aspect of progressing life is the greater and greater remoteness at which visible relations in the environment produce adapted relations in the organism.

§ 143. Similarly with the auditory faculty. So long as the susceptibility to sonorous vibrations is slight, and possessed by the body at large, there is nothing like what we call hearing. Only when the susceptibility comes to be intensified in one place, can a sound proceeding from a particular point in the environment, be distinguished from a tremor of the environment as a whole. After there has arisen a rudimentary ear, consisting of a dermal sac containing otolithes, which multiply the vibrations striking the skin that covers them as the primitive cornea concentrates the rays passing through it; then, a moderate sound at some distance or a slight sound close to it, may produce on the creature as great an effect as the violent shock of its entire medium produces on a creature not thus endowed. And along with this new sense there comes into existence a new set of correspondences—those between certain auditory impressions and consequent motions in the organism, and certain sound-causing powers and co-existent properties in adjacent bodies.

Successive improvements of this faculty, as of those already dealt with, expand the surrounding sphere throughout which certain relations in the environment cause adapted relations in the organism. It cannot be denied that though the minor irregularities involved by their special habits are considerable, yet, viewed in the mass, animals of higher and higher types show us greater and greater ranges in their auditory correspondences.

§ 144. The extension of the correspondence in space does not end with the perfecting of the senses. In creatures of comparatively-advanced organization, there arise powers of adjusting inner relations to outer relations that are far too remote for direct perception. The motions by which a carrier-pigeon finds its way home though taken a hundred miles away, cannot be guided by sight, smell, or hearing, in their direct and simple forms. Chased animals that make their way across the country to places of refuge out of view, are obviously led by combinations of past and present impressions which enable them to transcend the sphere of the senses. And thus also it must be with creatures that annually migrate to other lands.

In man, this secondary process of extension is carried still further. Though the correspondences he effects by immediate perception have a narrower range in space than those of some inferior creatures; and though in that species of indirect adjustment just exemplified, he is behind sundry wild and domestic animals; yet, by still more indirect means, he adjusts internal relations to external relations that are immensely beyond the appreciation of lower beings. By combining his own perceptions with the perceptions of others as registered in maps, he can reach special places lying thousands of miles away over the Earth's surface. A ship, guided by compass, and stars, and chronometer, brings him from the antipodes information by which his purchases here are adapted to prices there. From the characters of exposed strata he infers the presence of coal below; and thereupon adjusts the sequences of his actions to co-existences a thousand feet underneath. Nor is the environment through which his correspondences reach, limited to the surface and the substance of the Earth. It stretches into the surrounding sphere of infinity. It was extended to the moon when the Chaldeans discovered how to predict eclipses; to the sun and nearer planets when the Copernican system was established; to the remoter planets when an improved telescope disclosed one, and calculation fixed the position of the other; to the stars when their parallax and proper motion were measured; and, in a vague way, even to the nebulæ, when their composition and forms of structure were ascertained.

§ 145. Before leaving this general proposition, that the progress of life and intelligence is, under one of its aspects, an extension of the space through which the correspondence between the organism and its environment reaches, it may be well to remark that its truth is independent of all conclusions as to the modes in which the correspondence is developed. In the earlier part of the chapter I have filled up some of the gaps in our knowledge by reasonings that are partially hypothetical; and have thus opened the door to possible criticisms, which may at first sight be supposed to tell against the doctrine at large. But a moment's consideration will show that by whatever steps the senses of smell, sight, and hearing, arise, the result remains the same. Unquestionable facts form the substance of the argument. It is a fact that where the sense of touch is the only one definitely manifested, the correspondence between the organism and its environment extends only to that part of the environment by which the organism is bathed. It is a fact that the appearance of the higher senses, even in their most rudimentary forms, is accompanied by some extension of the space throughout which correspondences can be effected. It is a fact that the successive stages in the development of each sense imply successive enlargements of this sphere of space. And it is a fact that the advent of rationality is, among other ways, shown in the carrying of these enlargements still further.

Here, indeed, let me draw attention to the truth indicated by some of the above examples, that the extension of the correspondence in space is exhibited not in the ascending grades of animal life alone, but in the successive phases of human civilization, and is even now going on. From early races acquainted only with neighbouring localities, up to modern geographers who specify the latitude and longitude of every place on the globe—from the ancient builders and metallurgists, knowing but surface-deposits, up to the geologists of our day whose data in some cases enable them to describe the material existing at a depth never yet reached by the miner—from the savage barely able to say in how many days a full moon will return, up to the astronomer who ascertains the period of revolution of a double star—there has been a gradual widening of the surrounding region throughout which the adjustment of inner to outer relations extends.

It remains only to point out the additional evidence thus afforded that the degree of life varies as the degree of correspondence. On the one hand, each further extension of the correspondence in space adds to the number of external relations to which internal relations are adjusted—adds, that is, to the number of internal changes—adds therefore to the amount of life. On the other hand, the greater the space throughout which the correspondence reaches, and the more numerous the adjustments which can consequently be made, the greater must be the number of cases in which food is obtained and danger shunned. Whence we may clearly see how life and ability to maintain life, are two sides of the same fact—how life is a combination of processes the result of whose workings is their own continuance.

CHAPTER V.

THE CORRESPONDENCE AS EXTENDING IN TIME.

§ 146. It was pointed out some pages back (§ 136), that while the lowest *Protophyta* and *Protoza* display no manifest adjustments of internal changes to changes in the environment, the higher plants pass through cycles or states answering to the cycles of the seasons. Whether this should be regarded as a progress towards correspondence in Time, is doubtful. It may be said that since in a tree the budding, blossoming, ripening the fruit, and dropping the leaves, occur at the same times with fit external conditions, the inner sequences are conformed to the outer ones. But it may be replied that this is an incidental result of the perpetual adaptation of the internal actions to external co-existences (temperature, light, moisture), which, by passing through a series of variations, involve a parallel series of variations in the plant. It may be argued that the putting forth of leaves has reference simply to the then concurring influences, and has no direct reference to the subsequent nutrition of the fruit; that the true nature of these vegetative changes is seen in the fact that a tree will flower in the autumn if the heat be great enough; and that thus plant-life exhibits no true correspondence to *sequences* in the environment, but only to *co-existences* in it. To decide between these views is not easy; though on the whole the last seems the more rational. But at any rate, this species of correspondence in Time, if such it be, is of a vague kind compared with that properly so called.

Turning to those more definite cases which animal life displays, it is to be observed that in creatures possessing no other sense than that of touch, the sole external relations with which internal relations can be put in correspondence, are relations of *co-existence.* Only when there comes to be some amount of smell, or sight, or hearing, can *sequences* in the environment be met by adjusted sequences in the organism. The connexion between the tangibility of an adjacent body and some co-existent property possessed by it, is the only one to which, in a zoophyte, the connexion between irritation and contraction answers. Time is no more involved than Space. But when relations among things or attributes that are in any degree removed from the organism, become cognizable—when, for example, there exists incipient vision, and obstruction of light is often followed by a touch from the obstructing body—then, an organic response to an external sequence becomes possible: then the organism can move in anticipation of motion in an external body. Two phenomena in the environment, the one immediately succeeding the other, produce two phenomena in the organism in like succession.

Or, to present the proposition under another aspect:—As the simplest sequences, and those first perceived, are mechanical sequences; as mechanical sequences imply change of position; as change of position implies progress through Space; it follows that only when there is some degree of space-penetrating faculty, can there be any adaptation in the organism to changes of position in adjacent objects—any adjustment to external sequences—any correspondence in Time. After the ability to respond to the touches of surrounding bodies, the next advance is the ability to respond to those motions of them which precede touch; and since motion involves both Time and Space, the first extension of the correspondence in Time is necessarily coeval with its first extension in Space.

§ 147. Throughout the successive stages in the development of the senses, these two orders of correspondence progress together. In proportion as the distance at which a moving object is perceivable increases, the greater becomes the duration of the external actions, or chains of actions, to which the internal changes may be adjusted. Other things equal, the more remote any body, the longer must be the interval before it can act on the organism or the organism on it; that is—the longer must be the time between the outer antecedents and consequents with which the inner antecedents and consequents are put in correspondence. The inner and outer sequences shown in the pursuit of a heron by a hawk, are longer than those shown in the pursuit of a fish by a heron; and are so chiefly because the vision of a heron is wider than that of a fish. Without giving cases, it will be manifest that by the development of smell and hearing also, the correspondences are simultaneously extended in duration and distance. Not that they maintain a constant ratio. The connexion between them is variously modified by circumstances. The character of the environment, the particular powers of the organism in respect of locomotion, as well as other conditions, greatly affect it. All that can be said is, that the two kinds of extension are connate; and that, in so far as mechanical phenomena are concerned, they display throughout a general inter-dependence.

§ 148. This limitation—" in so far as mechanical phenomena are concerned "—serves to introduce the fact that, in respect to other orders of phenomena, the progress of the correspondence in Time has little or nothing to do with its progress in Space. Did all actions involve perceptible motion—were alteration of position a necessary accompaniment of every alteration, the two would be uniformly related. But as there are hosts of changes, chemical, thermal, electric, vital, which involve no appreciable mechanical change—as there are numberless changes of state which occur without changes of place; it results that, in the growth of internal adjustments to these, there is an extension of the correspondence in Time separate from, and additional to, that which arises from its extension in Space.

This second species of correspondence in Time is of a much higher order—is, in fact, a far more extended correspondence. For the ordinary mechanical sequences in surrounding bodies by which each organism is affected, are incalculably more rapid than the non-mechanical sequences. The motions of enemies or of prey, even when sluggish, are readily appreciable: a few seconds only, at most, are needed to bring about manifest changes. But the decay of a dead animal, or the ripening of fruit, or the drying up of a pool, or the hatching of an egg, occupies an immensely longer interval. One of these latter sequences has a duration a hundred, a thousand, a million times as great as one of the former; and the ability of the organism to adjust itself to them, implies a proportionate extension of the correspondence in Time.

Hence the fact that only when we come to creatures of comparatively high intelligence, do we meet with inner changes in adaptation to outer changes of a non-mechanical kind. For we must not class as coming under this head such actions of inferior animals as are adjusted to daily and annual modifications of the environment. These, like parallel actions in plants, are most likely nothing but the cumulative results of successive adaptations of the organism to successive co-existences in the environment. It is anatomically demonstrable that the pairing and nidification of birds in the spring, is preceded by constitutional changes which are probably produced by more food and higher temperature. And it is a rational inference that the whole series of processes implied in the rearing of a brood, are severally gone through, not with any recognition of remote ends, but solely under the stimulus of conditions continuously present.

An early stage of the higher kind of correspondence in Time, must be looked for where the period between antecedent and consequent is but a few hours. Birds that fly from inland to the sea-side to feed when the tide is out, and cattle that return to the farm-yard at milking-time, supply instances. Even here, however, there is not a purely intelligent adjustment of inner to outer sequences; for creatures accustomed to eat or to be milked at regular intervals, come to have adapted recurrences of constitutional states, and the sensations accompanying these states form the proximate stimuli to their acts. Nevertheless, we must not wholly exclude these instances from the category of advancing correspondence in Time; but must recognize them as imperfect and transitional forms of it, through which only the higher forms can be reached. For if we consider under what conditions only an inner sequence can be adjusted to some outer sequence occupying hours or days, it becomes plain that there must exist in the organism a means of recognizing duration. Unless the organism is differently affected by periods of different lengths, its actions cannot be made to fit slow external actions. When we pass from those mechanical sequences in which the motion of the external body itself serves the organism as a measure of duration, to those non-mechanical sequences which not only afford no measure but last incomparably longer, the only measure of duration available is one resulting from the periodic sensations of the organism itself. Naturally, then, these first examples of the higher correspondence in Time, arise where an internal periodicity agrees with an external periodicity. And naturally, in the cases next above these—cases implying some foresight of future events, such as is shown by a dog hiding a bone in anticipation of the time when he will be again hungry—there is a distinct reference to this same recurrence of organic states.

§ 149. The existence of so wide a gap between ordinary mechanical sequences and most non-mechanical sequences, in respect of the periods they occupy, joined with the circumstance that the adjustment of internal sequences to lengthened external sequences implies estimation of intervals, explains how it happens that only when we reach an advanced phase of intelligence, does this higher kind of correspondence in Time begin to exhibit a marked extension. Not that the transition is sudden. During the first stages of human progress, the method of estimating epochs does not differ in nature from that employed by the more intelligent animals. There are historical traces of the fact that, originally, the civilized races adjusted their actions to the longer sequences in the environment just as Australians and Bushmen do now, by observing their coincidence with the migrations of birds, the floodings of rivers, the flowerings of plants. And it is obvious that the savages who, after the ripening of a certain berry travel to the sea-shore, knowing that they will then find a particular shell-fish in season, are guided by much the same process as the dog who, on seeing the cloth laid for dinner, goes to the window to watch for his master. But when these phenomena of the seasons are observed to coincide with recurring phenomena in the heavens—when, as was the case with the aboriginal Hottentots, periods come to be measured partly by astronomical and partly by terrestrial changes; then we see making its appearance a means whereby the correspondence in Time may be indefinitely extended. The sun's daily movements and the monthly phases of the moon having once been generalized, and some small power of counting having been reached, it becomes possible to recognize the intervals between antecedents and consequents that are long apart, and to adjust the actions to them. Multitudes of sequences in the environment which, in the absence of answering functional periods, cannot be directly responded to by the organism, may be discerned and indirectly responded to when there arises this ability of numbering days and lunations. Given a unit of Time and a faculty of registering units, and the internal actions may be adjusted to countless non-mechanical actions going on externally, which, though the least conspicuous, are often the most potent in their effects.

This higher order of correspondence in Time, scarcely more than foreshadowed among the higher animals, and definitely exhibited only when we arrive at the human race, has made marked progress during civilization. The lowest tribes of men who wander from place to place as the varying supplies of wild animals, roots, and insects, dictate, do not adapt their conduct to periods exceeding a year in duration. Hardly worthy to be defined as creatures "looking before and after," their actions respond to few if any sequences longer than those of the conspicuous and often-recurring phenomena of the seasons. But among semi-civilized races we see, in the building of permanent huts, in the breeding and accumulation of cattle, in the storing of commodities, that longer sequences are recognized and measures taken to meet them. And when united in higher social states, men show, by planting trees that will not bear fruit for a generation, by the elaborate educations they give their children, by building houses that will last for centuries, by insuring their lives, by struggling for future wealth or fame, that in them, internal antecedents and consequents are habitually adjusted to external ones which are extremely long in their intervals. Especially is this extension of the correspondence in Time displayed by progressing science. Beginning with the sequences of day and night, men advanced to the monthly changes of the moon, next to the sun's annual cycle, next to the cycle of the moon's eclipses and the periods of the planets; while modern astronomy determines the vast interval after which the Earth's axis will again point to the same place in the heavens, and the scarcely conceivable epoch after which planetary perturbations repeat themselves.

When, as in these cases, the sequences exceed in length the lives of individual men, the correspondence is effected by the agency of many men whose actions are co-ordinated. An astronomer who computes the elements of a comet of brief period, and who, after the lapse of certain years, months, and days, turns his telescope to that region of the heavens in which the expected body shortly makes its appearance, shows in himself the entire correspondence between an internal series of changes and an external series. But when centuries pass between the predilection and its fulfilment, we see that by the help of written symbols, the proceedings of successive men are united into one long sequence, displaying the same adjustment to an external sequence as though it had occurred in a single man surviving throughout the interval. Perhaps nothing more strongly suggests the conception of an embodied Humanity, than this ability of Humanity as a whole to respond to environing changes which are far too slow to be responded to by its component individuals.

§ 150. The extension of the correspondence in Time, like its extension in Space, involves an increased amount of life and renders possible a greater continuance of life. Each longer sequence recognized implies an adjustment of a new set of internal relations to a new set of external relations—implies an additional series of vital actions—implies, therefore, an increased number and heterogeneity of the combined changes which constitute life. At the same time, the adjustment of the organism to these successively longer sequences, is itself an avoidance of dangers or a seizing of advantages; and is consequently a process of self-preservation. As we have seen, the ascending grades of brute life illustrate this, and it is illustrated by human progression. The civilized races, by recognizing slower changes and providing for more remote results than the hand-to-mouth-living savage does, obviously meet more numerous contingencies and secure greater longevity; while, in the meeting of these more numerous contingencies a higher degree of vital activity is involved. It may be argued with some plausibility, that the like is true even of the adjustment of our conceptions to those immense periods involved in the larger generalizations of astronomy and geology. For little as the recognition of these modifies human actions directly, yet indirectly, by abolishing old theories of creation and humanity, it ultimately produces a powerful effect on the conduct of the race.

CHAPTER VI.

THE CORRESPONDENCE AS INCREASING IN SPECIALITY.

§ 151. Otherwise considered, the evolution of life is an advance in the Speciality of the correspondence between inner and outer relations. In part, this is an aspect of the processes described in the last two chapters; and in part it is a further and a higher process. Just as we saw that in so far as mechanical phenomena are concerned, the extension of the correspondence goes on *pari passu* in Space and in Time, but that the extension of the correspondence in Time afterwards takes in many other orders of phenomena; so, though at first the increase of the correspondence in Speciality is inseparable from its extension in Space and Time, yet it presently comes to include innumerable correspondences not comprehended under either of these. Objectively, the development of the correspondence is essentially one; but the limitations of our intellects prevent us from grasping it as one; and it is an inconvenience accompanying the presentation of it in parts, that the divisions overlap one another.

The first specialization of the correspondence occurs on passing from those simplest organisms whose environments are homogeneous both in Space and Time, to those whose environments are homogeneous in Space but heterogeneous in Time. The yeast-cell, touched on all sides by the elements it requires, and during its short life kept under the needful conditions, exhibits a correspondence in the highest degree general. But the tree which, though constantly bathed by nutritive materials, assimilates them only under particular states of the environment, exhibits, in the adjustment of its internal changes to the recurring external changes, some advance towards speciality of correspondence.

The next step of the same nature—the step which distinguishes, so far as it can be distinguished, the animal kingdom from the vegetal one—takes place when, relatively to the needs of the organism, the environment is heterogeneous both in Time and Space. To the lowest living things, the integrable matter is everywhere present under uniformly available conditions. To plants in general, it is everywhere present, but *not* under uniformly available conditions. To animals in general, it is *neither* everywhere present nor present under uniformly available conditions—it exists in particular bodies irregularly dispersed, which can be obtained only by particular actions. And thus, change from a general diffusion of food to a localization of food, involves a further specialization of the correspondence. The organism now lives only on condition that contact with special masses of matter shall be followed by the special acts required to utilize them. In the *Amœba*, which wraps itself round and gradually includes the small nutritive fragments it meets with, we see that even before there are either prehensile or digestive organs the existence of its food in a solid form, implies that the organism must respond differently to the contacts of solid matter and of liquid matter; and this is a progress towards speciality of correspondence.

When there arises the primary division of the tissue into stomach and skin—when the established differentiation in the environment is met by an established differentiation in the organism—when to the ability to distinguish solid from liquid matter, comes to be added the ability to distinguish different orders of solid matter from one another; there are foreshadowed those many higher specializations which accompany the development of the senses. These we have now to consider.

§ 152. Out of the primordial irritability which (excluding the indeterminate types that underlie both divisions of the organic world) characterizes animal organisms in general, are gradually evolved those various kinds of irritability which answer to the various attributes of matter. The fundamental attribute of matter is resistance. The fundamental sense is a faculty of responding to resistance. And while in the environment, associated with this attribute of resistance, are other attributes severally distinctive of certain classes of bodies; in the organism, there arise faculties of responding to these other attributes—faculties which enable the organism to adjust its internal relations to a greater variety of external relations—faculties, therefore, which increase the speciality of the correspondence.

We see this not only in the rise of the senses that are affected by the sapid, odorous, visible, and sound-producing properties of things, but also in the series of phases through which each sense advances towards perfection. For every higher phase shows itself as an ability to recognize smaller and smaller differences, either of kind or degree, in the attributes of surrounding bodies; and so makes possible still more special adjustments of inner to outer relations.

In the case of touch, a progress is early shown in the power to distinguish a large moving mass from a small one by the force of its collision. Even zoophytes, which contract bodily if their tentacles are roughly handled but draw in particular tentacles only if these are touched lightly, have reached this stage. When, as in higher creatures, a muscular system and a concomitant muscular sense are developed, there results an appreciation of relative hardness in the objects met with; as is proved by the differences between the actions which follow the contact with soft and hard bodies respectively. Afterwards textures become cognizable, and also amounts of tenacity; as illustrated in the act of a spider testing the strength of its web. The possession of well-differentiated prehensile organs, makes perceptible the sizes and shapes of the things laid hold of; and the conduct is modified accordingly. When the combined appliances of touch and muscular sense are fully developed, as in man, we find that between the extremes of hardness and softness a great number of gradations can be appreciated; that an immense variety of textures can be known tactually; and that endless objects can be identified by their differences of size and shape, ascertained by the fingers only.

That specialized touch called taste, which may be generally, though not accurately, described as a sense serving to distinguish soluble matters from insoluble matters, presents a series of gradations of like kind. To the lower families of creatures, which if not without exception aquatic are in all cases surrounded by a liquid that has water for its chief constituent, the insoluble bodies are one with the inorganic bodies, while the soluble mostly answer to the organic. Matter which permanently continues undissolved in the sea or in a river, is stone or earth; while matter which, though soluble, is found in a solid form, is something that is or has been alive. Hence, to those lowest creatures which feed on any organic substance, the soluble and the insoluble—the things that have taste and the things that are tasteless—stand respectively for food and not-food. From this stage upwards, successive specializations, of which we may presume the first to be in an ability to distinguish organic matter into animal and vegetal, display themselves in the narrowing of the classes of things which are eaten. Fish that take particular baits, insects and quadrupeds that feed on particular plants, illustrate this. Obviously, it is neither needful nor practicable to trace out this progress in detail. It suffices to notice that the higher animals perceive an increased number of gustable differences; and that in man the sense of taste, besides serving to identify a great variety of edible substances, aids the chemist and the mineralogist in classifying those inorganic compounds which are in any degree soluble.

Smell which, as before suggested (§ 140), has probably a common origin with touch and taste, and is gradually differentiated from them, passes through parallel stages of development. At first a kind of anticipatory taste, and in common with taste employed to distinguish nutritive from innutritive matters, it progresses in speciality as the food is specialized; or, to put the facts in logical order—the ability to select special food is usually dependent on the minuteness of the differences which the smelling faculty can appreciate. This is not so throughout, for prey is in many cases recognized by other means than scent; but it is so with most insects and plant-eating quadrupeds, as well as with a considerable proportion of creatures that are carnivorous. These gradations in the olfactory sense, most clearly displayed in the mammalia, reach in some of those that hunt by scent to a great height. The dog which, with nose to the ground, traces out his master, shows us that he can do more than distinguish by scent one class of bodies from all other classes: he can even distinguish a particular individual belonging to that class.

The increasing speciality of the correspondences effected by means of vision as it develops is still more conspicuous. The lowest form of vision appears to be nothing beyond a sensitiveness to the proximity of a body which intercepts the light. Such surrounding changes as cause marked obscurations are alone responded to. When the sensitive tract on which the rays are concentrated is such that a part of it can be stimulated without the stimulation of the whole, there arises an ability to perceive adjacent objects by the light they reflect. Dark and light bodies thus come to be distinguished; and we may presume that further progress of like nature makes appreciable smaller and smaller gradations in the transitions from whiteness to blackness: so adding to the number of things discriminated. An ability to recognize differences in the quality of the light probably arises simultaneously. Things that are red, yellow, and blue, work unlike effects on the organism; as well as those that are white and black. Familiar facts clearly show that in the evolution of the visual faculty, the progress is towards a capacity to discriminate a greater variety of intensities of colour, of intermediate tints, and of degrees of light and shade. As there is developed a wider retina, marked differences in the areas occupied by images cast on it become appreciable; and hence arises a possibility of distinguishing differences of bulk in adjacent objects. The approach of a large body changes the state of a greater portion of the retina than the approach of a small one: the result being an appropriate difference of action. And as in the case of amounts of light and qualities of colour, successive advances of this kind bring with them perceptions of smaller unlikeness. Finally, there is reached the power to recognize not size only but shape. A minuter division of the sensitive tract into separate nervous elements, renders it a fit instrument for this. Employed by an organism of proportionate complexity, an eye of complex structure gives different impressions, both according to the *numbers* of its component nerve fibres simultaneously affected, and according to the *particular combinations* of them simultaneously affected; and the particular combinations, varying as they do with the forms of the bodies seen, serve as stimuli to the properly-adjusted actions. All which several kinds of visual development, reaching great heights among the superior animals, unite in giving man the power to identify by the eye innumerable different objects; and so to make innumerable special adaptations in his conduct.

Similarly with hearing. At first nothing but a sensitiveness to concussions affecting the whole environment, this sense, when localized and developed, becomes a means of distinguishing the strengths of the vibrations. A moderate sound near the auditory organ produces a different effect from one causing a violent tremor of the whole surrounding fluid; and slowly as the multiplying apparatus of which the ear essentially consists, is developed, more numerous degrees of intensity become perceptible. The result we see in animals which listen, or pursue, or seek refuge, according as some neighbouring noise is faint, or moderate, or startling. Higher endowments of the faculty are also accompanied by increased ability to discriminate qualities as well as quantities of sounds. Birds which answer one another in the woods and which when caged may be taught definite melodies, must recognize many differences in pitch. Parrots, whose imitations exhibit great variety in *timbre* as well as great compass, show a power to appreciate those secondary qualities by which tones of the same pitch are distinguished from one another. By most domestic quadrupeds, especially such as answer to their names, marked contrasts of pitch, or of *timbre*, or of both, are responded to. And among men the auditory faculty reaches a development which, besides enabling them to recognize numerous adjacent creatures, various mechanical operations, countless natural phenomena, by the accompanying sounds, also enables them to identify unseen persons by the loudness, pitch, and *timbre* of their voices, and even to perceive the particular states of feeling in which such persons then are.

Throughout the animal kingdom, then, the specialization of the senses measures the specialization of the correspondences between inner and outer relations—is a means to this specialization. Alike in the differentiation of the senses from one another, in the differentiation of each sense into the divisions which eventually constitute it, and in the differentiations of these into the minute subdivisions that make possible the appreciation of minute distinctions, we see a succession of subjective modifications fitting the organism to respond to a greater and greater number of those objective modifications which characterize things in its environment.

§ 153. While the developing faculties of touch, taste, smell, sight, and hearing, have been making it possible for the organism to respond to smaller differences in the simpler properties of things, there has been growing up a power of responding to those more complex properties of things which are not cognizable by sensation alone. This makes its appearance so gradually, and is so intimately associated with the direct functions of the senses, that it is scarcely possible to treat of the one without in some degree involving the other. Indeed, the boundary line was crossed in the foregoing section, when speaking of visible and of tangible form, and, to a smaller extent, in other cases.

The essential nature of this higher order of specialized correspondences will be more conveniently considered hereafter under another head. For the present it will suffice to say, that they are seen wherever Space or Time, or both Space and Time, are involved. Let us look at the matter in the concrete.

Observe, first, that in itself extension of the correspondence in Space implies increased speciality of correspondence, differing in kind from that above described though inseparable from it in origin. A higher development of the eye, brings simultaneously a greater ability to identify distant objects and a greater ability to discriminate between the sizes of near objects. And it is clear that these connate abilities to identify objects at a distance and to appreciate differences of apparent magnitude, give together a power of estimating distance: whence arise differences of action, according as the perceived enemies or prey are dangerously near or hopelessly remote; and these differences of action imply a new series of special correspondences. Manifestly, also, extension of the correspondence in Time involves analogous results. When, instead of recognizing only brief mechanical sequences which occur close to it, the organism recognizes mechanical sequences of longer duration, and afterwards non-mechanical sequences; and when, as a consequence, instead of meeting all sequences involving dangers by some one kind of defensive action, as retreat into its shell, it becomes able to meet them by different actions according to their lengths; the correspondence is, by implication, rendered more special.

This being understood, it will be seen that when the speciality of correspondence which exhibits itself in discriminating objects from one another, is united with the speciality of correspondence which exhibits itself in discriminating *distances* in Space or Time, there arises a new and a higher order of special correspondences; or more correctly—the previously-specialized correspondences are further specialized. And when, as during this same progress, there is developed a power of recognizing *direction* in space, the speciality is again increased. To another set of distinctions in the environment, there is another set of adjustments in the organism. These general truths will be best elucidated by a few illustrations.

On the approach of any large body, the shrimps left in a tide-pool make convulsive darts which may end in removing each of them to a greater distance from the approaching body, or in bringing it nearer, or in leaving it almost where it was. The random leaps which a flea makes in attempting to escape are of like nature; showing, as they do, no perception of the whereabouts of the pursuer. On the other hand, the movements of a crab or a fish when alarmed, are, like those of all higher creatures, *away* from the object to be escaped. The particular direction of something in the environment is responded to by appropriately-adjusted motions of the organism—the correspondence is comparatively special. When, again, not only the direction but the nature of a neighbouring body is known, either by its colour, or by the sound it makes, or by both—as exemplified in the deer that gallops away from a creature that barks but not from one that bleats, in the bee that flies towards a flower, in the trout that rises at one object but not at another—there is a still further specialization. And when magnitudes and forms and distances also come to be appreciated, there result those more definitely-adjusted actions by which the higher animals elude danger and secure prey—actions such as those of the chamois springing from crag to crag, of the hawk pouncing on its quarry, of the dog catching the morsel of food thrown to it, of the bird building its nest and feeding its young.

Similarly, that increased speciality implied by extension of the correspondence in Time, when joined with that increased speciality implied by a better discrimination of objects, gives origin to a further series of higher specializations. As fast as the sequences which are perceived to differ in length become more numerous; and as fast as there is a multiplication of things distinguished from one another; so fast do the adjustments of the organism to special actions going on around it augment in number geometrically. Save in respect to rapid mechanical changes, no correspondences of this order are shown by the lower classes of creatures; and, lacking as they do the ability to estimate time, even the higher mammals supply but few and imperfect examples of it. The lion that goes to the river-side at dusk to lie in wait for creatures coming to drink, and the house-dog standing outside the door in expectation that some one will presently open it, may be cited as approximative instances. But only when we come to the human race are correspondences of this degree of speciality exhibited with distinctness and frequency. In preparing his weapons against the approaching immigration of certain birds, in putting aside to dry the skins which he preserves for clothing, in making the fire by which to cook his food, the savage adapts his conduct to the special changes undergone by special bodies during definite intervals.

Eventually there is reached speciality alike in space, time, and object—the action of the organism is adjusted to the changes of a particular thing in a particular spot at a particular period. A large proportion of human actions, even among the uncivilized, are of this nature. The going to certain places, at certain seasons, to gather certain natural productions then fit for use; the endeavour to intercept an animal that is making for a retreat, by getting there before it; these, and numerous daily procedures, will serve as examples.

§154. Under this, as under previous aspects, an advance of the correspondence is clearly displayed in the course of human progress. The growth of classifications implies the establishment of more numerous distinctions among surrounding things, and a conforming of the conduct to their respective properties. Agriculture, as it develops, brings knowledge of the serial changes undergone by various plants and animals; while special materials, times, modes, places, are adopted for the production of each. Improvements in the Arts have involved an incalculable multiplication of special processes adapted to produce special changes in special objects. Our whole social life, alike in the manufactory, in the shop, on the highway, in the kitchen, displays throughout, the performance of particular actions towards particular things in particular places at particular times.

Above all in exact science, or rather in the actions guided by exact science, civilization presents us with a new and vast series of correspondences far exceeding in speciality those that came before them. For this which we call exact science is in reality *quantitative prevision*, as distinguished from that *qualitative prevision* constituting ordinary knowledge. The progress of intelligence has given the ability to say both that such and such things are related in co-existence or sequence, and that the relation between them involves such and such amounts of space, time, force, temperature, &c., &c. It has become possible to predict, not simply that under given conditions two things will always be found together, but to predict how much of the one will be found with so much of the other. It has become possible to predict, not simply that this phenomenon will occur after that, but to predict the exact time at which it will occur, or the exact distance in space at which it will occur, or both. And manifestly, this reduction of objective phenomena to definite measures gives to those subjective actions that correspond with them, a degree of precision, a special fitness, greatly beyond that possessed by ordinary actions. There is an immense contrast in this respect between the doings of the astronomer who, on a certain day, hour, and minute, adjusts his instrument to watch an eclipse, and those of the farmer who so arranges his work that he may have hands enough for reaping some time in August or September. The chemist who calculates how many pounds of quick-lime will be required to decompose and precipitate all the bi-carbonate of lime which the water in a given reservoir contains in a certain per-centage, exhibits an adjustment of inner to outer relations incomparably more specific than does the laundress who softens a tub-full of hard water by a handful of soda. In their adaptations to external co-existences and sequences, there is a wide difference between the proceedings of ancient besiegers whose battering rams were indeterminate in their actions, and those of modern artillery-officers, who, by means of a specific quantity of powder, consisting of specific ingredients, in specific proportions, placed in a tube at a specific inclination, send a bomb of specific weight, on to a specific object, and cause it to explode at a specific moment. And when we bear in mind that science, considered as the development of qualitative prevision into quantitative prevision, is not only thus distinguished by the relatively-high speciality of the correspondences it achieves, but that, as contemplated in its own progress, it has been ever becoming more accurately quantitative, more special in its previsions; it becomes obvious that even the most transcendent achievements of rationality are but the carrying further that specialization of the correspondences between the organism and its environment, which commences with the evolution of Life in general.

§ 155. This increase in the speciality of the correspondence, like its extension in Space and Time, is both in itself a higher life, and contributes to greater length of life. Inability to distinguish between surrounding bodies of different natures, must be attended by fatal errors in the conduct pursued towards them; while, conversely, the greater the power to recognize the multitudinous distinctions among such bodies, the greater must be the number of special adjustments that can be made to them, and the more frequent will be the self-preservation. The proposition is in essence a truism. It is almost a truism, too, to say that in proportion to the numerousness of the objects that can be distinguished, and in proportion to the variety of co-existences and sequences that can be severally responded to, must be the number and rapidity and heterogeneity of the changes going on within the organism—must be the amount of vitality. Indeed, there is no single formula which so well expresses the progress of Life, as this increase in the speciality of the correspondences between inner and outer relations. For, taking the extreme case, it is clear that did the actions of an organism accurately respond to all the co-existences and sequences of all things whatever in its environment, its life would be eternal. And it is equally clear that the innumerable internal changes involved in effecting the correspondence with innumerable external relations, would imply the highest conceivable degree of vital activity.

CHAPTER VII.

THE CORRESPONDENCE AS INCREASING IN GENERALITY.

§ 156. The adjustment of inner to outer relations progresses in generality at the same time that it progresses in speciality. This statement seems to involve a contradiction, but the contradiction is verbal only—the generality here referred to being of a different order from that which precedes speciality.

Primitive correspondences are general in the sense that those relations in the environment to which organic relations respond, are everywhere present and continuously present. During a summer's day, light, heat, and carbonic acid, bathe all the leaves of a plant; and the dependent chemical changes within the plant, go on for as many hours as the surrounding elements and actions remain in the same relation. Hence the correspondence, involving neither any special point in space nor any special movement in time, is of a very general nature. And the like holds with those inferior animals to which the environment presents both the disintegrating matter and the integrable matter in diffused forms. The generalities, however, to which the organism responds more and more the higher it advances, are not those exhibited by the mass of the environing medium, but those exhibited by the individual objects it contains; and generalities of this kind become cognizable only as intelligence is developed. Relations in the organism corresponding to relations displayed in common by several different groups of bodies, but not by other groups, can be established only when the organism has such experiences of various groups of bodies as enable it to distinguish among them. Only when there come to be recognized many different classes of objects, can there possibly arise subjective generalities parallel to those objective generalities which bind together classes of objects superficially unlike.

There are indeed generalities which diminish in extensiveness as the specialities increase in number—generalities which form the material out of which specialities are produced by continual subdivision. The growth of a response to the distinction between liquid matter and solid matter, then to the distinctions between liquid, inorganic, and organic matters, afterwards to those between liquid, inorganic, vegetal, and animal matters, implies a correspondence to generalities that are step by step less comprehensive; and each further multiplication of classes supposes a further reduction in the number of examples which each sub-class includes. These, however, are generalities which, under their obverse aspect, we considered in the last chapter. For all special correspondences are really the manifestations of general correspondences covering certain groups of cases. The precautionary acts of a barn-door fowl on seeing a hawk hovering above, are related to the acts of that hawk in particular, only as being like the acts of hawks in general. The correspondence is special, only in the sense of referring to the small class, hawks, instead of to the large class, birds.

But that advancing generality of correspondence here to be contemplated, shows itself in the recognition of constant co-existences and sequences other than those which characterize special classes—co-existences and sequences common to many classes that have come to be regarded as entirely unlike. Instead of being seen in a response to the constant relation between a particular scent, and the colour, size, form, actions, and cries, of the creature possessing it; this progress is seen in adjustments to such relations as those between bulk and weight, inanimateness and passivity—relations which extend beyond class limits, and obtain under great dissimilarities. Obviously the growth of generalities of this order must be opposite in direction to the growth of the preceding ones.

To trace up this growth from the lower to the higher forms of life, after the manner pursued in previous chapters, is extremely difficult if not impossible. For this species of correspondence does not manifest itself in distinct, uncombined forms. The extensions of the correspondence in Space and Time, as well as its increase in Speciality, are experimentally demonstrable; but an internal relation parallel to some external relation which is not peculiar to special classes of things, cannot be separately identified in the conduct. Giving origin to no particular acts, but serving simply to modify the acts otherwise originated, it can be discovered only by analysis of these.

Hence our course must be to ascertain the conditions under which alone advance of the correspondence in generality becomes possible; and then to show how the processes of evolution already described, give rise to these conditions. Let us do this.

§ 157. The establishment of a generality of this higher kind, embracing classes superficially dissimilar, implies a power of recognizing *attributes* as distinguished from the *objects* possessing them. Before any two properties that are found together under many varieties of size, form, colour, texture, temperature, motion, &c., can have their constant relation of co-existence responded to by the organism, the organism must be able to identify these two properties, as separate from their accidental accompaniments. The formation of special class-generalities, which group together clusters of phenomena that greatly resemble one another in *all* respects, requires no distinct parting of attributes. But where the resemblance is confined to some one essential relation common to many cases which in other respects differ, it is clear that unless the elements of this relation are separately cognizable there can be no response to it.

And now the truth to be noted is that increase of the correspondence in speciality, inevitably brings about this parting of attributes. There cannot be a multiplication of distinguishable classes, without there being a simultaneous approach to the perception of properties as distinct from objects. For if, ascending from the lowest creatures by which but few attributes are cognizable, we advance to those capable of being impressed by a greater and greater number of attributes, it is clear that in proportion as the groups of attributes become increasingly varied and special, there must be more frequent *dissociations* of particular attributes from the rest. Forms, colours, sizes, sounds, scents, motions, are found in all combinations. These two kinds of animals are alike in everything but colour; those two agree in colour but differ in form and scent; and the others have little in common but size. The property A occurs here along with the properties B, C, D; there along with C, F, H; there along with E, G, B; and so on with each property to a greater or less extent. Hence it must happen that by multiplication of experiences, the impressions produced by these properties on the organism will be disconnected, and rendered so far independent in the organism as the properties are in the environment. Whence must eventually result a power to recognize attributes in themselves, apart from particular bodies.

It may, indeed, be shown that progress of the correspondence in speciality, itself becomes possible only in proportion to the progress of this analysis. An analogy will best show the dependence. Let a chemist be required to produce artificially sundry compound bodies: what is implied in the execution of his task? The implication is that he knows the composition of each of these bodies.

But what does knowledge of their composition pre-suppose? It pre-supposes that they have been severally resolved into their constituents. And the formation of each required compound implies that its constituents are united in the right proportions. Well, the process of identifying any object is a synthesis of impressions, corresponding to certain united properties which the thing displays; and similarly implies a recognition of the separate impressions which correspond with the separate properties. The botanist who knows a particular flower not by the fructification alone, in which it is like many others—not by the number of its petals, which is a usual number—not by their forms in which they do not differ from these, nor by their colours in which they do not differ from those—not by the calyx, nor the bracts, nor the leaves, nor the stalk, separately considered, but by all these taken together; obviously effects the identification by a synthesis of attributes. And that which he does in a deliberate and conscious way, is done consciously or unconsciously in every case where an object is recognized as of special nature—is done in a degree proportionate to the speciality of the correspondence. Should it be said that this statement contradicts the previous statement, since the one represents the analysis of attributes as a *pre-requisite* to speciality of correspondence, while the other represents the analysis of attributes as *resulting* from increase of the correspondence in speciality, the reply is that the two processes go on in mutual dependence, perpetually acting and reacting on each other. Every advance in speciality presently renders the analysis of attributes more precise; and each step in the analysis of attributes makes possible a higher speciality.

Thus the course of evolution described in previous chapters, is necessarily accompanied by a disentangling of properties from one another, ending in an ability to recognize them in the abstract. Later and more slowly, relations both of sequence and of co-existence must come to be discriminated one from another, and segregated into kinds and degrees of relations. An increasing speciality in the adjustments to mechanical changes, pre-supposes an increasing decomposition of such changes into their elements —a growing power to distinguish velocity of motion, direction of motion, acceleration and retardation of motion, kind of motion in respect of simplicity or complexity, and so on; and where non-mechanical sequences also come to be responded to, a parallel analysis must accompany a parallel progress in speciality.

When these analyses have been considerably extended, there arises, and only then arises, a possibility of advance in generality of correspondence. Relations between properties possessed in common by objects of widely different kinds, can be perceived as soon as these properties are separately cognizable. And a still higher progress in the specialization of the correspondences, ultimately brings about this remaining step required for generalization of them. For if, as we have seen, the multiplication of special correspondences must be accompanied by the dissociation of variably-united attributes; then, when the variably-united attributes displayed by a group of different classes have been as it were disintegrated in the consciousness of the organism, the attributes that have not been disintegrated must begin to stand out from the rest, as remaining always constant amid these inconstancies. Hence there must be established in the organism a constant relation corresponding to the constant relation between these attributes; and this constitutes the advance in generality we are looking for. Further, as the comparatively-constant relations thus first generalized from the experience of but few classes, will, in the majority of cases, be proved by wider experience to be not everywhere constant; and as, by the accumulation of these wider experiences, the same process must be gone through with the comparatively-constant relations as before with the inconstant ones, with the result of bringing the still more constant relations into view; the progress must be from narrow generalizations to wider and wider ones. And this we know, *à posteriori*, to be the law which the progress conforms to.

§ 158. These explanations will at once show why the increase of the correspondence in generality is scarcely discernible in any but the most intelligent creatures. Necessary as it is that there should be a great advance in the speciality of the correspondences to produce the requisite separation of attributes; and necessary as yet further advance in specialization is to bring into view the constantly related attributes as distinguished from the inconstantly-related ones; it is only when that developed speciality of correspondence characterizing superior creatures is reached, that progress in generality of correspondence can begin. Hence the fact that while the higher mammals undoubtedly display some generalities of correspondence of the least abstract kind, it is only in the human race that this species of adjustment of inner to outer relations becomes conspicuous.

Human progression, however, exhibits to us, under this as under previous aspects, an immense increase in the harmony between the organism and its environment. Perhaps in no respect is the increasing correspondence wrought out by civilization more conspicuous than in the growth of generalizations, ever more numerous and more comprehensive. The enormous expansion of science which these latter ages have witnessed, mainly consists in the union of many particular truths into general truths, and in the union of many general truths into truths still more general. Illustrations are needless; for the proposition is familiar and admitted by all. It is enough simply to point to this great phenomenon as one of the many forms of the evolution we are tracing out.

A mere mention, too, of the fact that the generalizations of science immensely advance the arts, and through the arts minister to human welfare, will serve to show that increase of the correspondence in generality, like its other modes of increase, makes possible a greater duration of life. And a like brief reference to the concentration of thoughts and complexity of conceptions, which these wider generalizations imply, will sufficiently indicate the higher degree of life which accompanies this greater length of life.

CHAPTER VIII.

THE CORRESPONDENCE AS INCREASING IN COMPLEXITY.

§ 159. Another change in our stand-point affords us a view of progressing vitality which, though not the same in range with foregoing views, has much in common with them. As we saw that the extensions of the correspondence in Space and in Time, are partly reciprocal and partly not so—as we saw that increase of the correspondence in Speciality, while to some degree comprised under the extensions in Space and Time, includes very much beside; so we shall see that while, throughout a certain range of cases, growing Complexity is the same thing as growing Speciality, yet neither includes all that the other does. Much of the early advance in Speciality does not imply advance in Complexity; and the higher forms of the advance in Complexity cannot without straining be comprehended under advance in Speciality.

§160. Wherever we find nothing but a greater ability to discriminate between varieties of the same simple phenomenon, there is increased speciality of correspondence without increased complexity. It is thus with the progress from an eye that appreciates a difference between light and darkness, to one that appreciates degrees of difference between them, and afterwards to one that appreciates differences of colour and degrees of colour. It is thus with the progress from the power of distinguishing a few strongly-contrasted smells or tastes, to the power of distinguishing many slightly-contrasted smells or tastes. It is thus with the progress from that lowest form of hearing shown by a response to any violent tremor of the surrounding fluid, to those higher forms of it in which differences of loudness are recognized, and, by and by, differences of pitch and *timbre.* The insect which lays its eggs only on a plant having a particular odour, or the bird which is alarmed by a tone of a certain pitch but not by a tone of another, shows an adjustment of inner to outer relations equally simple with that shown by the snail which withdraws into its shell on being touched. Though the stimulus responded to is more special, it is not more complex. In each case a single undecomposable sensation is followed by certain muscular actions; and though these muscular actions are more intricate in the higher creatures than in the lower, yet the relation between antecedents and consequents is very nearly, if not quite, of the same order. But where the stimulus responded to consists, not of a single sensation but of several, or where the response is not one action but a group of actions, the increase in speciality of correspondence results from an increase in its complexity.

The development of vision repeatedly illustrates this. When, after that response to the habitual relation between opacity and solidity, which is first established, there arises a response to the relation between solidity and power to reflect light—when differences in the amounts and qualities of reflected light come to be recognized in connexion with differences of bulk—when there is acquired an ability to identify objects by form, as well as by colour and size conjoined; it is manifest that each successive stage implies the appreciation of larger clusters of attributes. The impression received by the organism from each object is a more complex impression—is increasingly heterogeneous. And when not only colour, size, and shape become cognizable, but also direction in space, distance in space, motion, kind of motion, direction of motion, velocity of motion—when, as by a falcon swooping on its quarry, all these external relations are simultaneously responded to; it is clear that the guiding perception must be compounded of many elements. There is no need to dwell on this truth as further exemplified during the evolution of the other senses; nor to trace up in detail that yet higher complexity which results when the several senses are employed together. A single extreme case will suffice. If we remember how a mineralogist, in identifying a mass of matter as of a kind fitted for a certain use, examines its crystalline form, its colour, texture, hardness, cleavage, fracture, degree of transparency, lustre, specific gravity, taste, smell, fusibility, magnetic and electric properties, &c., and is decided in his conduct by all these taken together; it will be obvious that throughout the higher range of cases, increase in the speciality of the correspondence involves increase in its complexity.

§ 161. But, as already hinted, we eventually rise to an order of correspondences in which the speciality and the complexity are no longer co-ordinate. A further advance in speciality is achieved by a more than proportionate advance in complexity. Let us look at an example or two.

The archer who points his arrow, not at the object he seeks to hit, but above it, and who varies the angle of elevation according as the object is far or near, exhibits something more than a special response to special stimuli; for his procedure implies consciousness of the fact that bodies projected through the air descend towards the Earth, and that the amount of their descent has some relation to the distance traversed. Besides a correspondence with certain perceived relations in the environment, there is implied a correspondence with the law of certain other relations, not then present to the senses. Again, the engineer who erects a suspension-bridge competent to bear a specified strain, is guided less by his inspection and measurement of the river to be crossed, than by his knowledge of the strength of wrought iron, of the properties of the catenarian curve, of the composition of forces—his acquaintance with the universal truths of number, geometry, and mechanics. In these cases the complexity of the correspondence is greatly in excess of the speciality. To bring out this fact by a contrast:—It might fairly be said that the Indian fish which catches insects flying over the surface by hitting them with jets of water, exhibits an adjustment of inner to outer relations as special as that shown by the archer; but considering that in the fish, nothing more is implied than an automatic connexion between certain visual impressions and certain muscular contractions, it cannot be held that there is anything like the same complexity of correspondence. Similarily, though the strength of a spider's web may be as specially adjusted to the demands to be made upon it, as is that of the engineer's suspension-bridge; yet there is no comparison between the two adjustments in respect of the variety and elaborateness of the actions by which they are achieved.

What constitutes this excess of complexity? It is constituted by the addition of generalities to specialities. Each of these higher correspondences displaying what we call rationality, implies an adjustment of inner relations not simply to the particular outer relations perceived, but to sundry general relations not then perceived, but established by previous experience. And as we advance to correspondences of still greater complexity, we see that their leading characteristic is the increasing number of generalizations recognized, and involved in the process of adjustment. Indeed, the highest achievements of science, as exemplified in astronomy, show us that an exact adaptation of the actions of the organism to special actions in the environment, supposes a pre-establishment of general relations in the organism, parallel to *all* those general relations in the environment which these special actions imply.

§ 162. There seems no place fitter than this, for drawing attention to the important fact that an approximately-constant ratio is maintained between the *impressibilities* and the *activities* of the organism, in so far as their complexity is concerned. In the lowest animal types we see a touch followed by a withdrawal of the part touched—a single stimulus followed by a single motion. Gradually as we ascend, abilities to receive increasingly-complicated impressions, and to perform increasingly-complicated actions present themselves. And the truth here to be observed is, that the heterogeneity of the stimuli which can be appreciated is in general proportionate to the heterogeneity of the changes which can be displayed.

Note, first, that survival of the fittest ensures this connexion. As every advance consists in the adjustment of some further internal relation to some further external relation; and as the ability to recognize the external relation is useless unless there is an ability to modify the conduct appropriately; it is clear that for the better preservation of life, the passive and active elements of the correspondence must progress together. A power to perceive the direction and distance of an object must be accompanied by a power to specialize the movements; otherwise it can be of no service. The recognition of certain forms, colours, and motions, as those of an enemy, will not prevent destruction unless it is followed by such quick acts, such doublings, such leaps, as the enemy may be eluded by. Discrimination shown in the choice of materials for its nest, is so much faculty thrown away unless the bird has sufficient constructive skill for nidification. It will not profit the savage to discover at what seasons and what times of the tide particular fish are to be caught, unless he has dexterity enough to make and use hooks or nets for catching them. Everywhere it must on the average happen that each additional differentiation of the perceptions, opening the way for an additional differentiation of the actions, fails to benefit the species, and therefore fails to be established in the species, unless there goes along with it an additional differentiation of the actions.

This connexion between progress in the impressibilities and progress in the activities, is, indeed, otherwise necessitated; for they so act and react that the advance of either involves the advance of both. The general relation between irritability and contractility, which, in the lowest types of animal life, constitute one indivisible phenomenon, is a relation which the regulative and the operative divisions of the organism maintain throughout all their complications. They are co-ordinate in their origin; they are co-ordinate in their manifestations; they are co-ordinate in their evolution.

This truth becomes conspicuous when we contemplate the two functions under their most general forms—sensation and motion. Given an organism with certain sensory and motor faculties, what will happen from the increase of either? Higher powers of motion and locomotion must bring the organism into relation with a greater number of objects; and must therefore multiply its impressions. Higher impressibility must subject the organism to more frequent stimuli to action; and so must multiply its motions and locomotions. Again, varied activities entail variety among the relations in which a creature puts itself towards surrounding things; and hence entail variety among the modes in which surrounding things affect it. Conversely, the more various the impressions receivable from surrounding things, the greater must be the number of modifications in the stimuli given to the motor faculties; and hence, the greater must be the tendency towards modified actions in the motor faculties. Thus the progress of each is involved with the progress of the other, in respect both of activity and complexity.

This inevitable simultaneity in the development of the directive and executive faculties, will, however, be most clearly seen on analyzing a few cases. Take as one, the ability to recognize direction in space. At first this seems to imply development of the sensitive part of the nature only: an expansion of the retina sufficiently great to admit of its components being separately affected by images falling on them. But a little consideration shows that something more is required than ability to perceive differences between the positions of images on the visual tract. Taken alone, these differences are meaningless. They come to have meaning only when they are severally connected in the organism with those differences of motion required to bring its surface into contact with the things seen. Mere ocular impressions do not of themselves give ideas of space. Such ideas are products of a growing experience which proves that these impressions are due to objects that can be touched by particular muscular adjustments. Direction, therefore, cannot be perceived until there is a motor apparatus sufficiently developed to effect specialized movements. Consequently, the ability to perceive direction and the ability to take advantage of the perception, are necessarily connate. The recognitions of distances, of velocities, of bulks, of shapes, obviously imply the like conditions. So, too, is it with the variations of surfaces indicated by lights and shades: these variations have to be disclosed by corresponding variations in the adjustments of the muscles, before lights and shades can be interpreted. No definite idea of weight, as connected with visual appearances, can be arrived at until there is a power of lifting, either by jaws or limbs. Nor can degrees of hardness and unlikenesses of texture be perceived in surrounding objects, faster than the manipulative organs are perfected. Indeed, as these last instances show us, the inter-dependence is even more intimate than above alleged; for besides being required for the interpretation of impressions, muscular aid is required even for the reception of impressions in their higher forms. Perfect vision implies a focal adjustment of the eyes, an adjustment of their axes to the requisite convergence, a turning of them both towards the object, sometimes a turning of the head in the same direction, and sometimes also a turning of the body: all which preparatory acts are performed by muscles. Neither taste nor smell can be acute unless the muscles of the tongue and the chest do their parts in moving about the food or drawing in the air. Hearing, too, is imperfect unless the *membrana tympani* is strained by its muscles so that it vibrates in concord with each successive sound. Above all, the perceptions reached through touch show this dependence on the motor apparatus. A sensitive skin is but a small part of the requirement, as any one may prove by closing his eyes and applying his bare arm or leg to an unknown object. Tactual sensations are combined into ideas of extension, form, solidity, only when this sensitive skin is distributed over surfaces capable of deriving simultaneous or rapidly-succeeding sensations from different parts of the things touched; and these sensations must be joined with those muscular sensations accompanying the simultaneous and successive adjustments of the sensitive surfaces. There must be limbs to effect the larger and simpler adjustments, with appendages at the ends of them to effect the smaller and more elaborate ones. And only in proportion as these motor agencies become complex, can there be complexity in the tactual perceptions. But these motor agencies—these limbs and appendages with all the muscles they are moved by, are also the locomotive and manipulating organs; and the same completeness of structure which fits them to receive compound impressions, fits them to perform compound operations. The evolution of the sensitive or directive apparatus, is thus inseparable from the evolution of the muscular or executive apparatus.

§ 163. This all-essential relationship must detain us somewhat longer. It will be instructive to glance at the inter-dependence of the *recipio-motor* functions and the *dirigo-motor* functions (§ 18) as exhibited in the concrete. I refer to the sundry striking instances which the animal kingdom presents of unusual sagacity co-existing with unusual development of organs which, by the help of complex muscular arrangements, give complex tactual impressions.

Why touch, the simplest and earliest sense, should, in its higher forms, be more than any other sense associated with the advance of intelligence, will perhaps seem difficult to understand. The explanation lies in the fact that tactual impressions are those into which all other impressions have to be translated, before their meanings can be known. If we contemplate the general relation between the organism and surrounding objects, we see that before they can affect it, or it can affect them, in any important way, there must be actual contact. Eating, breathing, locomotion, the destruction of prey, the escape from enemies, the formation of nests and burrows, the bringing up of young, all imply mechanical actions and reactions between the animal and its environment. The space-penetrating faculties serve but as guides to these mechanical actions; and the impressions they receive are primarily used but as symbols of tangible properties and the relations among them. Hence, only as fast as the impressions gained through the skin and muscles become varied and complex, can there be a complete translation of the varied and complex impressions gained through the eyes, ears, and nose. The mother tongue must be as copious as the foreign; otherwise it cannot render all the foreign meanings. And thus, as seen in the facts referred to, a highly-elaborated tactual apparatus comes to be the uniform accompaniment of superior intelligence. But let us look at these facts.

Each great division of the animal kingdom supplies them.

The *Cephalopoda*, which in sagacity go far beyond all other *Mollusca*, are structurally distinguished from them in having several arms by which they can grasp an object on all sides, at the same time that they apply it to the mouth. Again, the crabs, which similarly stand at the head of the sub-kingdom *Articulata* bring their claws and foot-jaws simultaneously to bear on the things they are manipulating. Merely glancing at these instances furnished by the invertebrate classes, let us devote our attention to those which the vertebrate classes furnish.

It will be admitted that, of all birds, parrots have the greatest amount of intellect. Well, if we examine in what they differ most from their kindred, we find it to be in development of the tactual organs. Few birds are able to grasp and lift up an object with the one foot while standing on the other. The parrot, however, does this with ease. In most birds the upper mandible is scarcely at all moveable. In the parrot it is moveable to a marked extent. Generally, birds have the tongue undeveloped and tied down close on the lower mandible. But parrots have it large, free, and in constant employment. Above all, that which the parrot grasps it can raise to its beak; and so can bring both mandibles and tongue to bear upon what its hand (for it is practically a hand) already touches on several sides. Obviously no other bird approaches to it in the complexity of the tactual actions it performs and the tactual impressions it receives.

Among mammals it is unquestionable that as a general rule the *Unguiculata*, or those which have limbs terminating in separate digits, are more intelligent than the *Ungulata*, or hoofed animals. The feline and canine tribes stand psychologically higher than cattle, horses, sheep, and deer. Now, that feet furnished with several sensitive toes can receive more complicated impressions than feet ending in one or two masses of horn, is manifest. While, by a hoof, only one side of a solid body can be touched at once, the divided toes of, for example, a dog, can simultaneously touch the adjacent sides of a small body, if not the opposite sides. And when we remember how those toed quadrupeds of higher types, which cannot grasp with their feet, can nevertheless use them for holding down what they are tearing or gnawing, we see that they can recognize tangible relations of some complexity. Moreover, when we meet with any marks of sagacity among hoofed animals, as in the horse, we find that the lack of sensitive extremities is partly compensated for by highly sensitive and mobile lips, which have considerable powers of prehension. Here we are naturally reminded of the most remarkable, and perhaps the most conclusive, instance of this connexion between development of intelligence and development of the tactual organs—that seen in the elephant. I say most conclusive, because the elephant is markedly distinguished from allied tribes of mammals, alike by its proboscis and by its great sagacity. The association between the operative and regulative faculties stand out the more conspicuously, from the endowment of both being exceptional. On the intellect of the elephant there is no need to dwell: all know its superiority. The powers of its trunk, however, must be enumerated. Note first, its universality of movement in respect of direction. Unlike limbs, the motions of which are in most mammals more or less confined to the vertical plane, its flexibility gives it as wide a range of positions as the human arm can take—wider, indeed, than can be taken by a single arm; and thus the elephant can ascertain the relations in space, both of its own members and of surrounding things, more completely than all other creatures save the *Primates*. Again, the trunk can grasp bodies of every size, from a pea to a tree stump; and by this means can perceive a far greater variety of tangible forms than any of the lower mammalia. The finger-like projection with which the trunk terminates, is affected by minor variations of surface; and so, textures and the details of shape can be made out, as well as general extension. Its ability to lay hold of and to lift bodies of many sizes and natures, opens the way to a knowledge of weight as connected with visible and tangible attributes. The same power of prehension, used as it habitually is for the breaking-off of branches, brings experiences of the tenacity and elasticity of matter; and when employed, as these branches often are, for driving away flies, the swinging of them about must yield impressions even of momentum—impressions which the ability to throw small bodies (as gravel over the back) must tend to strengthen. Further, the trunk's tubular structure fits it for many hydraulic experiments, that disclose sundry mechanical properties of water unknown to other quadrupeds; and this same peculiarity, rendering it possible to send out strong blasts of air which produce motion in the light bodies adjacent, so brings yet another class of experiences. Thus, the great diversity of tactual and manipulatory powers possessed by the elephant's proboscis, is not less remarkable than is the creature's high sagacity—a sagacity which, dwelling in so ungainly a body, would otherwise be inexplicable. Passing to the *Primates*, we find repeated, under other forms, this same relation between evolution of intellect and evolution of tactual appendages. Not more in the contrasts between them and inferior mammals is this seen, than in the contrasts between the genera of the *Primates* themselves. The prehensile and manipulatory powers of the lower kinds are as inferior as are their mental powers. On ascending to the very intelligent anthropoid apes, we find the hands so modified as to admit of more complete opposition of the thumb and fingers; the bones of the forearms so articulated as to give the hands greater powers of rotation; the arms attached to the body in such a manner as allows them increased range of lateral movement. In all the more developed of the order, the fore-limbs are so constructed that an object can be grasped in one hand while it is being manipulated by the other, or by the lips and teeth—can be held at the most convenient distance from the eyes—can be applied to any part of the body, or any neighbouring object. So that far more complex perceptions of size, shape, structure, texture, hardness, weight, flexibility, tenacity, &c., and of their various combinations, can be reached by them than are accessible to creatures whose limbs are less elaborately constructed.

How, in man, *recipio-motor* and *dirigo-motor* structures and functions are both still further elaborated, scarcely needs saying. As contemplated from an obverse point of view, the connexion between them is abundantly exemplified in works on natural theology. All that we need here notice is the extent to which, in the human race, a perfect tactual apparatus subserves the highest processes of the intellect. I do not mean merely that the tangible attributes of things have been rendered completely cognizable by the complex and versatile adjustment of the human hands, and that the accompanying manipulative powers have made possible those populous societies in which alone a wide intelligence can be evolved. I mean that the most far-reaching cognitions, and inferences the most remote from perception, have their roots in the definitely-combined impressions which the human hands can receive.

This inter-dependence of the impressibilities and activities as displayed in the course of human progress, is so striking and instructive as to demand special attention, even at the cost of a further suspension of the general argument.

§ 164. All developed science, consisting as it does of quantitative prevision—dealing as it does with *measured* results, is lineally descended from that simplest kind of measurement achieved by placing side by side the bodies held in the hands. Our knowledge of the forces governing the Solar System is expressed in terms that are reducible, by an ultimate analysis, to equal units of linear extension, which were originally fixed by the direct apposition of like natural objects.* And the undeveloped sciences that have not yet passed the stage of qualitative prevision, depending for their advance, as they do, either on experiments requiring skilful manipulation or on observations implying dissection and other analogous procedures, could not have reached this stage in the absence of a highly-developed manual dexterity.

But this intimate connexion between the directive and executive faculties, is even still more clearly to be traced in certain other phenomena of civilization. This mutual dependence of the regulative and operative powers, which Anaxagoras had a glimpse of when he uttered his hyperbolical saying that animals would have been men had they had hands, is remarkably and conclusively exemplified in the reciprocity of aid between the Sciences and the Arts. It needs but a little analysis to show that under their psychological aspects, Sciences and Arts represent what in their lowest forms we call sensory and motor processes. The perceptions gained through sensory organs and the actions performed by motor ones, respectively rise, by combination, into scientific generalizations and manufacturing operations. A comparison of the extremes does not very obviously show this; but on looking at the transitions the filiation becomes manifest. It cannot be denied that the complex perceptions of which each sense is the agent, together with the still more complex perceptions reached by co-operation of several senses, are forms of the organism's impressibility; nor that the combinations, more and more involved, of motive, locomotive, and manipulative powers, are forms of the organism's activity. It cannot be denied that out of these complex perceptions, woven into general ideas still more complicated, finally arise the previsions of

* For explanation, see essay on "The Genesis of Science.'

science; nor that all handicrafts, and after them the higher processes of production, have grown out of that manual dexterity in which the elaboration of the motor faculty terminates. If, looking at the entire range of phenomena, we seek out the essential nature of the changes an organism goes through in adjusting itself to the environment—if we divide these changes, as we must, into those which external objects impress on it, and those by which it appropriately modifies its relations to the external objects—if we name these respectively, the directive changes and the executive changes; we see clearly that sensations, perceptions, conceptions, generalizations, and all forms of cognition, come under the one, while contractions, locomotions, and all kinds of operations, come under the other; and that Science and Art, so far as they are separable at all, belong, the one to the first division and the other to the last.

This truth being recognized, we shall perceive the significance of the reciprocity of services between the Sciences and the Arts. Each great step towards a knowledge of laws has facilitated men's operations on things; while each more successful operation on things has, by its results, facilitated the discovery of further laws. Astronomy and agriculture, geometry and the laying out of buildings, mechanics and the weighing of commodities—these were among the earliest relations of the two. Presently geometry, as developed by artificers, acted on astronomy; and astronomy reacted to the great advancement of geometry. Through the medium of the scales, mechanics, joined with the science of number, influenced the metallurgic arts, gave definite alloys, introduced metallic instruments, and by so doing advanced the accuracy of astronomical and other observations, and improved all those processes of production for which metallic tools are employed. Metallurgy, too, by supplying plane and concave mirrors, initiated optics; and the first proposition in harmonies was reached by the help of strings and weights which the arts furnished. As we advanced to modern times the connexion becomes increasingly conspicuous. We see it in the dependence of navigation on astronomy, magnetism, and meteorology; and the aid rendered to magnetic and meteorologic science by navigation—in the development of geology by mining, quarrying, and well-sinking; and the guidance which geology now gives to the search for coal, metals, and water. The compounds and elements with which chemistry deals were at first brought to light by the arts; and the arts are now all more or less dependent on chemistry. There is scarcely an observation now made in science, but what involves the use of instruments supplied by the arts; while there is scarcely an art-process but what involves some of the previsions of science. This fact, that the mutual aid becomes ever more active, further elucidates the general truth we are contemplating. For as, when tracing upwards the directive and executive faculties, we found that their dependence on each other grows continually greater—that complete visual and tactual perceptions are impossible without complex muscular adjustments, while elaborate actions require the constant overseeing of the senses; so, among these still higher cognitive and operative processes, we now find a reciprocity such that each further cognition implies elaborate operative aid, and each new operation implies sundry elaborate cognitions.

These correlations are equally well, or even still better, seen in the objective appliances used. We may properly say that in its higher forms, the correspondence between the organism and its environment is effected by means of supplementary senses and supplementary limbs. All observing instruments, all weights, measures, scales, micrometers, verniers, microscopes, thermometers, &c., are artificial extensions of the senses; and all levers, screws, hammers, wedges, wheels, lathes, &c., are artificial extensions of the limbs. The magnifying glass adds but another lense to the lenses existing in the eye. The crowbar is but one more lever attached to the series of levers forming the arm and hand. And the relationship which is so obvious in these first steps, holds throughout. This being perceived, a meaning becomes manifest in the fact that the development of these supplementary senses is dependent on the development of these supplementary limbs, and *vice versâ*. Accurate measuring instruments imply accurate instruments for turning and planing; and these cannot be made without the aid of previous measuring instruments of some accuracy. A first-rate astronomical quadrant can be produced only by a first-rate dividing engine; a first-rate dividing engine can be produced only by first-rate lathes and cutting tools; and so, tracing the requirements backwards, it becomes obvious that only by repeated actions and reactions on each other, can directive and executive implements be brought to perfection. Only by means of artificial limbs can artificial senses be developed; and only through artificial senses does it become possible to improve artificial limbs.

Lastly, it may be remarked that not only do the directive and executive elements of the correspondence develop hand in hand, but the complications they reach have analogous characters. That union of generalities with specialities which we found to distinguish the highly-involved cognitions of Science, is visible also in the highly-involved operations of Art. Just as a particular conclusion in Science is reached by putting special data to a general principle, which general principle concreted by other data gives other conclusions; so, a particular art-product is obtained by subjecting to special manipulations the material obtained by some more general process, which material subjected to other manipulations, yields other art-products.

§ 165. And now on returning from this long and elaborate digression, bringing with us the conceptions arrived at, we find that they serve greatly to elucidate the subject of the chapter—the increase of the correspondence in complexity.

While tracing the inter-dependence of impressibilities and activities as they evolve into regulative and operative faculties of high orders, the growing complexity of the correspondence has been illustrated in several ways. The progressing heterogeneity of the impressions received through each sense has shown it; and still more the progressing heterogeneity of the combinations of impressions yielded by co-operation of the senses. The compounding and re-compounding of the muscular movements, alike of each limb by itself and of the limbs and body together, have further exemplified it. Above all it has been shown in the advance of this reciprocity between the *recipio-motor* acts and the *dirigo-motor* acts, which, becoming ever closer, becomes ever more involved; so that eventually a single accurate perception implies complex muscular adjustments, and a single exact operation implies the guidance of complex perceptions. In all which it is manifest that, as alleged at the outset, advance in speciality of correspondence is in its higher forms achieved through advance in complexity of correspondence.

How this increase of the correspondence in complexity which we have followed up through the higher animals to Man, has been continuing during civilization, has just been shown: the advance of the Sciences and the Arts abundantly exemplified it. One note-worthy fact, however, remains to be named. Human evolution, considered under this aspect, is not adequately represented objectively by the developing Sciences and the Arts. It must be looked at also on its subjective side as developing faculty. While there has been advance in the complexity of the cognitions and operations that have been age by age attained to, there has been advance in the ability to receive complex cognitions and perform complex operations.

For scientific and artistic progress is due not simply to the accumulation of knowledge and of appliances: the impressibilities and the activities have themselves grown to higher complications. There is evidence from various quarters that the minds of the inferior human races cannot respond to relations of even moderate complexity; much less to those highly-complex relations with which advanced science deals. According to the traveller Lieutenant Walpole, it is remarked of the Sandwich islanders, by their teachers, "that in all the early parts of their education, they are exceedingly quick, but not in the higher branches, that they have excellent memories, and learn by rote with wonderful rapidity, but will not exercise their thinking faculties." That is to say, they can readily receive simple ideas but not complex ones. Again, of the Australians we read that "some of them are very quick at acquiring knowledge, but they have no power of combination or concentration." * The reports of Hindoo schools disclose, though in a less marked manner, the same fact. One of the reasons assigned in the United States for not educating negro children along with white children, has been that after a certain age they "do not correspondingly advance in learning—their intellects being apparently incapable of being cultured beyond a particular point." And this statement, which might else be suspected of bias, agrees with that made respecting the same race in Africa by Sir Samuel Baker, who says;—"In childhood I believe the negro to be in advance, in intellectual quickness, of the white child of a similar age, but the mind does not expand—it promises fruit but does not ripen." † So, too, of the Andaman children we read that they "catch up words readily and repeat them, but seem incapable of connecting words with corresponding ideas." ‡ Even the finest uncivilized races show

* See Proceedings of the Ethnological Society.

† The Albert N'yanza. Vol. I, p. 289.

‡ Trans. Eth. Soc. New Series, Vol. IV. p. 210.

us the like limitation. "Without genius for discovery, and incapable of generalizing," the New Zealanders "are nevertheless apt at acquiring the rudiments of learning" * * * "boys at ten years of age are more intelligent than English boys; but, as a rule, few New Zealanders could be taught to equal Englishmen in their highest faculties." * In all these cases, as also in the minor cases continually occurring among ourselves of inability to understand reasonings passing a certain degree of abstruseness, the interpretation is that the intellect has not reached a complexity equal to the complexity of the relations to be perceived. Not only with purely intellectual cognitions does this hold; it holds also with what we distinguish as moral cognitions. In the Australian language there are no words answering to justice, sin, guilt. Among most of the lower races, acts of generosity or mercy are incomprehensible. That is to say, the more involved relations of human actions in their social bearings are not cognizable. We must therefore conclude that the complex manifestations, intellectual and moral, which distinguish the large-brained European from the small-brained savage, have been step by step made possible by successive complications of faculty.

Having, in the previous chapters, pointed out how greater length of life and higher degree of life accompany increased speciality and increased generality of correspondences, it is needless to dwell on the fact that where both these unite in producing correspondences of increased complexity, the like result must happen. It may be added, however, that not only is this true of the more complex intellectual guidance which, through the medium of Science, advances the Arts; but it is true of the more complex emotional guidance which, by making social order possible, contributes to the greater individual safety that social order brings.

* Thompson's New Zealand. Vol. I, pp. 85-6.

CHAPTER IX.

THE CO-ORDINATION OF CORRESPONDENCES.

§ 166. Fully to comprehend the increase of the correspondence between the organism and its environment, in speciality, in generality, and in complexity, it is requisite to contemplate the facts under yet another aspect. We must look at the general conditions by fulfilment of which these more elaborate adjustments of inner to outer relations are made possible. The performance of a compound action in response to a compound impression, implies something more than a susceptibility to each of the several elements constituting the compound impression, and a power to effect each of the several motions constituting the compound action. It implies that the constituent sensations and contractions shall be combined after a particular manner—shall be co-ordinated; and the perfection of the correspondence will vary as the perfection of the co-ordination.

Let us take first a simple case, as that of the actions needed for escape from an enemy. When we rise from creatures in which the motion of some conspicuous adjacent object is responded to by random muscular movements, to creatures in which the muscular movements are such as to carry the body *away* from the dangerous object; we rise to an adjustment of at least two joined relations in the organism to two joined relations in the environment.

The strong visual impression produced by the adjacent moving object being the stimulus to activity; then, that the activity may be of the right kind, such modification of the impression as depends on the direction of the body in space must be recognized, and the activity modified accordingly. The impression which indicates dangerousness and that which indicates position, must together control the motor changes; and the control must consist in so ordering their respective amounts that the resulting motion may carry the organism away from the source of danger. When distance as well as direction becomes cognizable, and when the colour and shape of the object are distinguished as well as its mass, the stimulus is composed of a much greater number of elements, united after a special manner; and the more rapid, skilful, and varied the consequent actions become, the more elaborate and more perfect are the implied combinations of motor changes. While just as a wrong combination of motor changes involves a fall or other failure of action; so, a wrong combination of the separate stimuli entails a mistaken perception.

Space need not be occupied in tracing up these simple kinds of co-ordination. It is obvious that throughout the series of increasingly-compound perceptions, including even the recognitions of localities by identification of surrounding objects, the constituents of each perception co-operate after a particular manner; and that, as especially seen in this case of localities, it is only in virtue of a definite relationship among them that a definite perception is possible. No less obvious is it that the increasingly-complex actions by which higher creatures achieve their ends, succeed only in as far as the muscular contractions implied are fitly regulated in their order, their amounts, and their modes of conjunction.

§ 167. Advancing from these cases in which the directive stimuli, though heterogenous, are made up of elements that are simultaneously present to the senses, to the cases in which some of their elements are present to the senses and some not, we meet with a sensory co-ordination of a new and higher order. And where the responding motions, no longer occurring as an inseparable group, are divided by intervals that vary according to circumstances, we see a parallel progress in motor co-ordination. A creature which when pursued runs to its burrow, supplies us with an instance of the one; while an instance of the other occurs in any process which, like the building of a nest, is effected by instalments variously interrupted by other procedures. From the stage in which a single past impression unites with many present ones to compose a special stimulus, and in which the action completed at intervals is tolerably homogeneous in character, the advance is towards a union of many past impressions with present ones, and towards a kind of action increasingly heterogeneous in its instalments, as well as in the manner of their succession. In men's daily transactions, the complex sights, sounds, and muscular sensations, serving for immediate guidance, are co-ordinated with recollections of the persons, places, things, events, to which those transactions refer; and one who mistakes the hour at which certain business is to be done with certain people at a certain office, shows us how a failure arises from imperfect co-ordination of the past and present impressions constituting the directive stimulus. The operations by which wheat is sown, weeded, reaped, stacked, thrashed, winnowed, taken to market, and sold, compose a series of widely-different groups of actions (each consisting of many minor groups), divided by dissimilar and variable intervals, all combined to achieve a single end; and to achieve it they must be adjusted in a particular manner. The elaborateness of these advanced correspondences in which time past, time present, and time future are alike involved, and which have simultaneous reference to sundry places in space, is an elaborateness measured by the number of past impressions compounded with present ones, and past actions compounded with present ones. But the all-essential thing is the definiteness with which the combination is adapted to the combination of external circumstances—the goodness of the co-ordination.

§ 168. A still higher species of co-ordination growing imperceptibly out of the last, and vaguely seen even in the illustrations just given, involves not simply the union of past with present specialities, but the union of generalities with both. The perception received yesterday when the barometer stood at "Fair," together with the perception received to-day, when it stands at "Change," bring no conclusion unless joined to the generalization that a fall of the mercurial column commonly indicates rain. Nay, before a true inference can be drawn for to-morrow's guidance, these data must be joined with the further generalization, that only when the air is charged with water to a certain degree is rain indicated by a falling barometer. In other cases, as in that of a physician prescribing for his patient, many remembered observations of bygone symptoms, many observations of existing ones, and many general truths serving to interpret the changes that have taken place, must enter into that directive process which terminates in an appropriate course of treatment.

But the most developed form of co-ordination is that exhibited by quantitative science. In this, not only must specialities be combined with generalities after a perfectly definite manner; but there must be perfect definiteness in each constituent of the combination. The perceptions by which the data are obtained must have their elements so exactly co-ordinated as to give measured results. The laws of dependence must be so known that they can be expressed numerically. And the process by which, out of data and laws, the prevision is finally evolved, must have each step united with preceding and succeeding steps in a mode that is quite specific. An estimate of the horse-power required to move a given steam-vessel at a specified speed, involves these general truths:—that the resistance encountered by a body moving through fluid varies as the square of the velocity; that the area opposed by a vessel to the water varies as the squares of its dimensions; that the tonnage varies as the cubes of the dimensions; with sundry others. Particular forces, weights, specific gravities, lengths, breadths, depths, have to be combined with these general truths, each with each; and the results have to be further combined after particular modes. If one of the generalities be applied to the wrong specialities—if the formula for resistance be brought to bear, not on the figures representing sectional area, but on those representing tonnage—if the data be inexact, or the principles be misunderstood, or the calculation be erroneously performed, that is—if there be imperfect co-ordination of the various mental acts involved; a false conclusion is reached: there is a failure of cognition: the internal relations are not rightly adjusted to external ones, as is proved by the result.

It will further elucidate both this doctrine of co-ordination and the general doctrine of correspondence, if we consider how, for the perfect adjustment of inner to outer relations, there must exist in the first, elements and changes symbolizing all the essential elements and changes in the last. Undeveloped life is led by associations among some of the superficial attributes of things. Developed life is led by associations among those fundamental attributes on which the actions of the things depend. There is no invariable connexion between a loud sound and an adjacent enemy; and hence, creatures in which one of these serves as an index to the other, are often wrong in the adjustments of their internal relations to external ones. But the connexion between linear dimensions and solid contents, or between velocity and momentum, is constant, and therefore affords infallible guidance. Before this infallible guidance can be had, however, *all* the elements of the relation must be known. Whenever a group of inner relations, or cognition, is completely conformed to a group of outer relations, or phenomenon, by a rational process—whenever there is what we call an *understanding* of the phenomenon—the composition of the phenomenon is, in a sense, paralleled by the composition of the cognition. The law that the momentum of a moving body varies as its velocity multiplied into its weight, cannot be known until there exist in the mind conceptions answering to momentum, velocity, and weight; it cannot be known until there exist in the mind ideas of time, space, and matter, without which velocity and momentum are inconceivable; it cannot be known until there are processes of thought answering to those quantitative connexions which " varies as " and " multiplied into " indicate; nay, the law cannot be known until the states of consciousness symbolizing time and space, are so co-ordinated as to symbolize velocity; nor until the states of consciousness symbolizing velocity and weight are so co-ordinated as to symbolize momentum; nor until these three are again co-ordinated according to those laws of relation implied by " varies as " and " multiplied into." That is, every attribute necessarily involved in the phenomenon must have its internal representative; and the several laws of dependence among these attributes must be each represented by some constant relation among their representatives.

These facts bring out into yet clearer light, the general doctrine variously presented in the preceding chapters. That in these highest manifestations of Life produced by the culture of civilization—these quantitative previsions which imply such intense vital action while they so greatly subserve self-preservation by facilitating commerce and the arts—there should be this elaborate and complete co-ordination of inner relations to symbolize outer relations, serves as a crowning illustration of the truths, that Life is the maintenance of a correspondence between the organism and its environment, and that the degree of Life varies as the degree of correspondence. The many proofs which have been given that the life and the correspondence advance hand in hand, become doubly conclusive on finding that the two culminate together.

CHAPTER X.

THE INTEGRATION OF CORRESPONDENCES.

§ 169. There is one more point of view from which the phenomena of Life must be contemplated. We have to note how, out of co-ordination, there grows up integration. Compound impressions, as well as the compound motions guided by them, continually approach in their apparent characters to simple impressions and simple motions. The co-ordinated elements of any stimulus or of any act ever tend towards union; and eventually become distinguishable from one another only by analysis. Further, the connexion between stimulus and act also becomes constantly closer; so that at last they seem two sides of the same change.

Only by virtue of this law do the higher kinds of correspondence become possible. In its absence, complex impressions could not generate complex actions with the needful rapidity; nor would there be time for that immense multiplicity of adjustments which developed life displays. If the two organic changes which constitute sensation and motion, did not, in superior creatures, follow with greater rapidity than the withdrawal of a snail into its shell follows the touch of its horn, all those correspondences with the environment which imply any quickness of adaptation would be impracticable. If the period that elapses between the gaze of a young child at a stranger and the fit of crying that follows (a period during which the component visual impressions are being co-ordinated), were habitually paralleled in the perceptions of adults—if compound cognitions were not formed, and the appropriate operations produced by them, in periods incomparably briefer, human life would cease.

The necessity for this progressive integration will be most clearly understood if, regarding sensations as symbols and perception as the interpretation of groups of symbols, we observe what takes place with verbal symbols and the meanings they convey. Where intelligence is but little evolved, a single sensation, as of scent, serves the organism for an index of the combined attributes with which such scent is connected; and similarly, in undeveloped language a simple sound is used to indicate a complex idea. In either case, this system answers very well within narrow limits. But a large increase in the number of correspondences requires another system. By scent, only some objects can be distinguished: many are scentless. Simple sounds and marks are too few in number to represent any considerable variety of ideas. Hence, in either case, compound symbols must be used before there can be a great multiplication of the correspondences. Things that are without odour, and things that are alike in odour, can be divided into sub-classes when impressions of colour and size, as well as of scent, can be appreciated. And when simple sounds are endlessly modified by articulations, and simple signs are replaced by composite signs, it becomes possible verbally to indicate an infinity of objects, acts, qualities, &c. But on what condition only does this more elaborate language become serviceable? or, to confine the attention to one division of it—What is required before composite written signs can supplant simple written signs? It is required that the constituent elements of each composite sign shall be so efficiently co-ordinated, so rapidly united in the act of perception, so integrated, as to become practically one. Had the letters that make up every word to be separately identified, as the child identifies them when learning to read, the system would be of little or no use. Able, though it might be, to express with precision all verbal articulations, it could never compete with the limited system of simple signs, did it remain thus cumbrous in its application. Similarly with the primordial language of perception. If the several colours, size, shape, motion, direction, and distance, of an object, had to be successively identified by the creature perceiving it—if the object had to be spelled out in this deliberate fashion; the method of recognition by combined sensations would yield in utility to the method of recognition by a single sensation. Universal in its powers, it would yet be too slow of use to satisfy the requirements. In both cases, however, the progressive integration of the component correspondences removes this difficulty, by practically reducing the compound signs to simple ones. A word made up of a dozen letters comes eventually to be recognized as quickly as a single letter. The host of impressions involved in the perception of a carriage, seemingly take no more time to receive and interpret than a single sound or taste. And thus there is immeasurable gain in the speciality of the correspondences, without loss in their rapidity. Let us glance at the results.

§ 170. It is needless to dwell on the apparent simultaneity with which the many visual sensations given us by an object, arouse those ideas of tangible extension, of resistance, of texture, with which experience has joined them: the entire group of sensations and the inferences drawn from them, seeming to constitute but a single state of consciousness. Nor is it requisite to do more than indicate the exceeding precision with which the most complex assemblages of these symbols are instantly distinguished from nearly identical assemblages; as shown in our ability to recognize by a single look, a particular person, and even his particular mental state. But to convey a vivid idea of the manner in which this integration of correspondences subserves the perceptions, it will be well to describe an experiment showing its extreme strength and rapidity.

We judge of distance by at least three separate indications. When the observed object is known to us, the angle it subtends, or, rather, the space which its image covers on the retina, aids in the estimate. The particular focal adjustments which the eyes undergo to obtain distinct vision, and which are accompanied by certain muscular sensations, assist. And the muscular sensations accompanying due convergence of the visual axes, supply a third evidence. In ordinary vision these indications agree. But by that ingenious instrument of Professor Wheatstone's invention—the Pseudoscope—the last two are made to contradict each other. The muscular actions by which the visual axes are adjusted being the more marked, and accompanied by the stronger sensations, give the preponderating evidence; and the result is that when looked at through the Pseudoscope, convex objects seem concave and concave objects seem convex. By particular management, however—that is, by adding to the evidence from focal adjustment some further evidence—the verdict of consciousness may be suddenly reversed. If, after contemplating the inside of a cup and wondering at its apparent convexity, the cup be turned laterally little by little, so that the outside gradually comes into view and the opening grows more elliptical, there presently arrives a time when the perception all at once changes, and the cup is seen under its ordinary aspect. Now the fact here to be remarked as so significant, is the impossibility of any intermediate or hesitating judgment. Notwithstanding the conflict of evidence, there is, save at the moment of change, a definite perception either of concavity or of convexity. The perception is not incomplete or obscure, but perfectly distinct. The preponderating impressions dragging with them all those other impressions which they habitually imply, produce the same effect as though these other impressions were actually received, instead of the opposite ones being received. The co-ordinated sensations have become so integrated that no considerable part of the group can be present to consciousness without the whole group being present.

With the executive processes as well as with the directive processes, this integration takes place. A long-employed combination of muscular actions is at last almost undecomposable. The tricks of walk, of attitude, of manual action, which children acquire, and of which it is so difficult to break them, furnish examples. We have another example in stammering, which, commencing as it often does with imitation, becomes, when once established, next to incurable. So, too, is it with peculiarities of handwriting. The motions of the fingers having by years of practice been coordinated in a particular manner, cannot be otherwise coordinated without a degree of labour to which few are equal. Though, by moving them slowly and with attention, the fingers may be made to produce differently-formed letters; yet, on the attention being relaxed and the usual speed resumed, the letters re-acquire their old characters. Similarly in all handicrafts, chains of perpetually-repeated muscular actions, however complex, eventually approximate in rapidity and ease to simple motions; and, at the same time, cease to be capable of modified adjustment—tend more and more to produce one another automatically—grow inseparable—become integrated.

Similar integrations go on between cognitions and the operations guided by them. In the child learning to walk, or to lay hold of a neighbouring object, or to pronounce a word, there is a deliberate and conscious modification of the motions in obedience to the sensations. But in after-years the various muscular adjustments by which, from minute to minute, the intentions are fulfilled, follow the will instantaneously and without oversight of the intellect. While absorbed in gossip, the seamstress makes stitch after stitch by a co-ordination of sensations and actions that has become next to instinctive. When deep in thought—"absent in mind," as the phrase is—the occurrence of particular perceptions will often be unconsciously followed by the actions appropriate to them: sometimes with ludicrous effect. The start on one side caused by a loud noise close at hand, or the throwing out of the arms to regain the balance after having slipped, shows us how directive and executive processes, originally quite distinct, come to be so united that one follows the other not only instantly and without volition, but often without the possibility of prevention. Even where the impressions and motions are both extremely complex, the law may be traced; witness the feats of a skilful billiard-player. In one of his strokes we see the relative positions of the three balls to one another, to the cushions, and to the pockets, all united into a complex visual impression co-ordinated with the greatest nicety; we see the direction of the cue, its adjustment to the ball, the strength of its impact, and the quality of its impact, all accurately modified to suit the requirements; and we see that by long habit the compound impression has been so united with the compound action, that the one follows the other almost mechanically. No reasoning or calculation is required; or, indeed, is permissible. For it is notorious that in games of skill, any lengthened consideration or active interference on the part of the higher faculties, almost inevitably causes a failure. The direct guidance that has been established between the constituent sensations and constituent motions, must be allowed free play; and success becomes sure in proportion as, by constant co-ordination, the combined changes become practically one change.

In all which we may perceive how that automatic character shown in the simple correspondences of inferior creatures, is gradually assumed by more complex correspondences—how that integration which the reflex and purely instinctive correspondences perfectly exemplify, is partially exemplified by all higher correspondences.

§ 171. Not only to the constituents of immediate perception, to the elements of composite motion, and to the combination of the two, does this law apply; it applies also to the highest processes of cognition. The most advanced conceptions of science display it equally with the achievements of manipulatory skill. For making a generalization is, in reality, integrating the various separate cognitions which the generalization includes—uniting them into a single cognition. After there has been a mental accumulation of facts presenting a certain community of nature (remembered first as isolated facts and after further experience colligated as facts having some resemblance), there suddenly, on the occurrence perhaps of some typical example, arises a cognition of the relation of co-existence or sequence common to the whole group: the particular facts, before loosely aggregated, all at once crystallize into a general fact—are integrated. The mode in which this result is brought about, is the same in these highest cases as in the lowest cases. Continuous repetition of experiences in which any two sensations are always joined, any two muscular contractions constantly performed together, or any perception uniformly followed by a special motion, results in the greater or less integration of the component changes; and, similarly, continuous repetition of those more complex experiences which, though superficially unlike, one and all present the same fundamental relation of co-existence or sequence, ultimately establishes a union in thought between the elements of this relation, and still-multiplying experiences go on consolidating the union. It will be obvious without details, that the same thing holds respecting the generalization of generalizations. The integration of correspondences is traceable from the simplest up to the most elaborate of the intellectual processes. And in the last, as in the first, the effect is to simplify the directive and executive actions, and so to make practicable those adjustments that would else fail from the too slow succession of the processes they involved. For as the perception of a complex object would commonly be useless if the percipient had to spell out the constituent sensations; so, any series of compound experiences which, embodied in a generalization, afford valuable guidance, would be of little or no service if every member of the series had to be separately recollected before the guiding cognition could be formed.

§ 172. This gradual union of the elements of any internal change by which the organism adapts its acts to an external co-existence or sequence, has been, in common with previous traits of advancing correspondence, abundantly displayed in the course of human evolution. Progress in integration has been a necessary accompaniment of progress in speciality and complexity, since without it highly special and complex correspondences cannot be achieved; and hence in proportion as civilization has displayed the last it must have displayed the first. The one having been illustrated in detail it is therefore needless to illustrate the other. Similarly, greater length and degree of Life, involved as they are by greater complexity and speciality of correspondence, have accompanied that greater integration which has rendered these possible.

CHAPTER XI.

THE CORRESPONDENCES IN THEIR TOTALITY.

§ 173. Thus then we find illustrated in all ways the truth enunciated at the outset, that the connexions among vital actions directly or indirectly correspond with the connexions among actions in the environment. That method by which we sought out the fundamental fact on which to base a Synthetic Psychology, is justified by its results. On comparing the phenomena of mental life with the most nearly allied phenomena—those of bodily life—and inquiring what is common to both groups, a generalization was disclosed which proves on examination to express the essential character of all mental actions. Regarded under every variety of aspect, intelligence is found to consist in the establishment of correspondences between relations in the organism and relations in the environment; and the entire development of intelligence may be formulated as the progress of such correspondences in Space, in Time, in Speciality, in Generality, in Complexity.

As hinted more than once, these several modes in which the advance of the correspondence displays itself, are but so many different aspects of one mode. The vast array of phenomena which, for convenience' sake, we have considered under distinct heads, form in reality one general, continuous, and inseparable evolution. By going on simultaneously, the various orders of progress described have rendered one another possible. Every kind of advance has opened the way for advances of other kinds; and these again have reacted in like manner. All have been furthered by each; and each has been furthered by all. Not only is extension of the correspondence in Time, at first rendered possible only by its extension in Space; but ultimately, as in the researches of astronomers, the greatest extension of the correspondence in Space is achieved through its extension in Time. Not only does progress of the correspondence in Time and Space involve increase in its speciality: but, eventually, that immense increase in speciality implied by the making of telescopes and chronometers, gives a new progress to the correspondence in Time and Space. On the one hand, such greater complexity of the correspondence as is shown by discriminating between objects which have many attributes in common, amounts to advance in its speciality; and, on the other hand, advance in speciality is that without which greater complexity of correspondence cannot be reached. While, by the correspondence to higher generalities, the way is opened for more complex and more special correspondences; it is by accumulated experiences of such more complex and more special correspondences that the correspondence to still higher generalities is made possible. At both extremes of the evolution this *consensus* among the various orders of correspondence is clearly traceable; but the further the development advances the more intimate does the *consensus* become. If we consider the results of improved vision in some inferior species, we see that besides bringing within view a wider region, and so extending the correspondence in Space, and besides giving earlier notice of approaching prey or enemies, and so extending the correspondence in Time; it brings a greater power of discriminating among near objects, and so initiates correspondences of higher speciality. Similarly, on observing what takes place in the man of science who adjusts a further inner relation to some futher outer relation—say the relation between an electric current and the magnetization of iron —we see that while the discovery is an advance in speciality of correspondence, it immediately leads to a variety of advances in all orders of correspondences. It makes possible generalities and specialities of correspondence to the phenomena of terrestrial magnetism. Through the galvanometer it leads to adjustments, both general and special, between inner relations and the outer relations subsisting among electrical phenomena of various orders. In the same way it does the same thing in respect to an immense range of chemical phenomena. And it similarly brings within reach a vast series of thermal phenomena. Through the agency of the electric telegraph which has also grown out of it, it makes possible hosts of special correspondences between men's actions and the changes occurring at remote points on the Earth's surface; it enables astronomers to ascertain the relative longitudes of observatories with the greatest nicety; and by supplying them with an improved means of registering meridional transits, it gives better data for calculating the distances and motions of the stars, for determining the structure of our Sidereal System, for ascertaining the motion of the Sun through space. In such among other ways has this one advance facilitated other advances of all orders and in all directions; and, in a greater or less degree, the like happens from every advance.

So that from the lowest to the highest forms of life, the increasing adjustment of inner to outer relations is one indivisible progression. Just as out of the homogeneous tissue with which every organism commences, there arises by continuous differentiation and integration, a congeries of organs performing separate functions but remaining mutually dependent, or rather growing more mutually dependent; so, the correspondence between the actions going on inside of the organism and those going on outside of it, beginning with some simple homogeneous correspondence, gradually becomes differentiated into various orders of correspondences, which, though constantly more and more subdivided, maintain a reciprocity of aid that grows ever greater. These two progressions are in truth parts of the same progression. Without dwelling on the fact that the primordial tissue displays the several forms of irritability in which the senses originate, and that the organs of sense, like all other organs, arise by differentiation of this primordial tissue—without dwelling on the fact that the impressions received by these senses form the raw materials of intelligence, which arises by combination of them and must therefore conform to their law of development—without dwelling on the fact that intelligence advances *pari passu* with the advance of the nervous system, and that the nervous system has the same law of development as the other systems—without dwelling on these facts, it is sufficiently manifest that as the progress of organization and the progress of correspondence between the organism and its environment, are but different aspects of the evolution of Life in general, they cannot fail to harmonize. In this organization of experiences which constitutes evolving Intelligence, there must be that same continuity, that same sub-division of function, that same mutual dependence, and that same ever-advancing *consensus*, which characterize the physical organization.

§ 174. That Intelligence has neither distinct grades nor is constituted of faculties that are truly independent, but that its highest manifestations are the effects of a complication that has arisen by insensible steps out of the simplest elements, is a conclusion equally thrust upon us when we turn from the characteristics of the organism to the characteristics of the environment. Every act of Intelligence being, in essence, an adjustment of inner to outer relations, it results that as, in the advance of this adjustment, the outer relations increase in number, in complexity, in heterogeneity, by degrees that cannot be marked, there can be no precise demarkations between the successive phases of Intelligence. The space through which the correspondence gradually extends, has no definite boundary up to which a certain order of mind is competent but beyond which another order is required. No exact length of time can be named as the greatest to which the actions can be adjusted by one supposed species of guiding principle. Among the specialities of external phenomena it is impossible to fix on that which can be reached, but not passed, by a particular denomination of mental endowment. Environing objects and environing actions passing as they do into higher and higher complexities by gradations that are insensible, it is impossible to draw among them a line up to which some alleged kind of intellectual process may go but beyond which it cannot go.

Evidently then, the classifications current in our philosophies of the Mind can be but superficially true. Instinct, Reason, Perception, Conception, Memory, Imagination, Will, &c., must be either conventional groupings of the correspondences, or divisions among the operations which are instrumental in effecting the correspondences. However widely contrasted they may seem, these various modes of Intelligence cannot be anything else than either particular ways in which the adjustment of inner to outer relations is achieved, or particular parts of the process of adjustment.

That there are distinctions among the groups of phenomena thus named is doubtless true. But, when considered in their essentials, it becomes manifest that some of them merge into one another as branches into a trunk, and that the rest are but the different constituents of which some branch is made up.

§ 175. Here a new region of inquiry opens before us. Having found that all the phenomena of Psychology come within this formula which unites them with those of Physiology, we have now to see what distinguishes the one group from the other. We decided that we should "best fulfil the requirements of clear exposition by first exhibiting mental evolution as it may be most generally conceived, and subsequently specializing the conception" (§ 130). One of these steps has been taken in the preceding chapters, which have presented psychological truths under their broadest aspect as biological truths. It remains to take the other step by presenting psychological truths under their differential aspect.

For, as was pointed out in §§ 54, 55, though objective Psychology, as dealing with a certain order of vital activities, comes within Biology considered as the entire science of Life, it nevertheless constitutes a sub-science clearly marked off from the rest; just in the same way that Chemistry, although a part of the general science of Molecular-Physics, is rightly erected into a separate sub-science, because it deals with the re-distributions of heterogeneous molecules instead of the re-distributions of homogeneous molecules.

That which distinguishes the science of psychical life from the science of physical life, we found to be the distinct cognizance which it takes of phenomena outside the organism as well as of phenomena inside the organism. We saw that, passing beyond the question with which Physics deals—What is the connexion between two phenomena A and B in the environment? and passing beyond the question with which Physiology deals—What is the connexion between two changes *a* and *b* in the organism? the question with which Psychology deals is—What is the connexion between these two connexions? How is the relation *a* to *b* in the organism adjusted to the relation A to B in the environment? While admitting, or rather asserting, that Biology at large tacitly recognizes phenomena in the environment as implied by phenomena in the organism, I pointed out that the recognition is but tacit, and that the great mass of biological inquiries are carried on without reference to it; whereas in Psychology the recognition of environing actions and relations is avowed and all-essential—is repeated from moment to moment—is a necessary component of every proposition.

The distinction then drawn in the most general way, has recently been illustrated in various special ways. For while, that we might obtain the most comprehensive conception of psychological phenomena, we returned to the most general point of view, and have throughout the foregoing chapters looked at them simply as vital phenomena coming within the definition of Life as a whole; we have met with abundant proof that the truths of Psychology differ from the truths of Physiology by taking for their subject-matter neither the relations of inner acts nor the relations of outer acts, but the adjustments of the inner to the outer. On glancing back over these chapters it will be found that in the first two of them, treating of purely physical life as exemplified in plants and in animals of the very lowest types, the environment was recognized in the smallest possible degree: only that part of it which touched the organism had to be taken into account. But the moment we rose to a type of creature which adjusts certain organic relations to relations of which both terms are not presented to its surface, we passed into adjustments of the psychological order. As soon as there exists a rudimentary eye capable of receiving an impression from a moving object about to strike the organism, and so rendering it possible for the organism to make some adapted movement, there is shown the dawn of actions we distinguish as intelligent. As soon as the organism, feebly sensitive to a jar or vibration propagated through its medium, contracts itself so as to be in less danger from the adjacent source of disturbance, we perceive a nascent form of the life classed as psychical. That is to say, whenever the correspondences exhibit some extension in Space or in Time, some increase of Speciality or Complexity, we find we have crossed the boundary between physical life and psychical life. In so far as it deals at all with the adjustments of inner actions to outer actions, Physiology limits itself to the few in which the outer actions are those of agents in actual contact with the organism—food, aërated medium, and things which produce certain effects by touch (as insects which fertilize flowers); thus leaving to Psychology all other adjustments of inner to outer actions. So that, practically, the spheres of the two are as clearly divided as the organism is divided from its environment by its limiting membrane.

§ 176. Quite apart, however, from the considerations thus recalled and enforced, we see here the need for a more specific and definite interpretation of that mental evolution which the preceding chapters exhibit in its fundamental form. The presentation of Intelligence as an adjustment of inner to outer relations that gradually extends in Space and Time, that becomes increasingly special and complex, and that has its elements ever more precisely co-ordinated and more completely integrated, leaves us with a conception which obviously requires further development. The various degrees and modes of Intelligence known as Instinct, Memory, Reason, Emotion, Will, and the rest, must be translated in terms of this conception. If, as above alleged, the several grades of Mind and its component faculties, are phases of the correspondence and factors in the correspondence, they can be interpreted as such; and to complete the argument it is needful that they should be so interpreted.

We have now, then, to enter upon another department of our subject. Closing here the General Synthesis, and carrying with us the fundamental truth evolved by it, it remains to found upon that fundamental truth a Special Synthesis.

PART IV.

SPECIAL SYNTHESIS.

CHAPTER I.

THE NATURE OF INTELLIGENCE.*

§ 177. The two great classes of vital actions called Physiology and Psychology are broadly distinguished in this, that while the one includes both simultaneous and successive changes the other includes successive changes only. The phenomena forming the subject-matter of Physiology present themselves as an immense number of different series bound up together. Those forming the subject-matter of Psychology present themselves as but a single series. A glance at the many continuous actions constituting the life of the body at large, shows that they are synchronous—that digestion, circulation, respiration, excretion, secretion, &c., in all their many sub-divisions, are going on at one time in mutual dependence. And the briefest introspection makes it clear that the actions constituting thought occur, not together, but one after another.

No impassable chasm between them is thus constituted however. Even were the highest psychical life *absolutely* distinguished from physical life in the way alleged, which

* This chapter and all its successors composing Part IV., remain in substance the same as in the original edition. The numerous changes of expression, omissions of superfluous passages, and occasional additions of explanatory sentences, have been such only as conduce to the clearer presentation of the doctrines set forth—the doctrines themselves being unchanged. I name this for a reason sufficiently indicated in the preface.

we shall presently see reason to doubt, it would still be true that psychical life in its lower phases is not thus distinguished: the distinction arises only in the course of vital progression. That gradual differentiation and integration, seen alike in the evolution of organic structures and in the evolution of the correspondence between their actions and actions in the environment, is also seen in the separation of this correspondence into its two great orders. While through it have resulted the various subordinate divisions of the correspondence, through it also has resulted this fundamental division. We will look at a few of the facts.

Passing over the small animals moved by cilia, in which the independence of the many irritations and motions simultaneously going on is manifest—passing over the Zoophytes, in which moderate local stimulations produce local contractions without affecting the organism as a whole—passing over these creatures devoid of nervous systems, let us consider what happens when the nervous system has attained some development. In such so-called *Radiata* as the Star-fish, each of the several like divisions composing the body "is connected with a ganglionic centre, that seems to be subservient to the functions of its own division alone, and to have little communication with, or dependence upon, the remainder." * The result is that what elementary psychical changes the creature manifests, take place simultaneously in different parts of its body: each part separately responding to the impressions made on it. And hence the fact that for a length of time after being divided from one another, the rays severally continue to exhibit their ordinary actions. In the *Articulata*, specially fitted by their structure for showing it, this dispersion of the psychical life is well brought out by experiment. "The *Mantis religiosa* customarily places itself in a curious position, especially when

* Carpenter's *Principles of Comparative Physiology.* Fourth edition, p. 654.

threatened or attacked, resting upon its two posterior pairs of legs, and elevating its thorax with the anterior pair, which are armed with powerful claws: now if the anterior segment of the thorax, with its attached members, be removed, the posterior part of the body will still remain balanced upon the four legs which belong to it, resisting any attempts to overthrow it, recovering its position when disturbed, and performing the same agitated movements of the wings and elytra as when the unmutilated insect is irritated; on the other hand, the detached portion of the thorax, which contains a ganglion, will, when separated from the head, set in motion its long arms, and impress their hooks on the fingers which hold it.—If the head of a *Centipede* be cut-off, whilst it is in motion, the body will continue to move onwards 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. * * * * If the body be opposed in its progress by an obstacle of not more than half of its own height, it mounts over it, and moves directly onwards, as in its natural state; but if the obstacle be equal to its own height, its progress is arrested, and the cut extremity of the body remains forced up against the opposing substance, *the legs still continuing to move.*" * All which facts imply that even in animals of this comparatively-advanced organization, both orders of vital changes are simultaneous and successive: the differentiation of the psychical from the physical life is but slight. Even among *Vertebrata* of high types, this differentiation is by no means complete. Many of the actions are partly voluntary, partly automatic; and may be performed with various degrees of consciousness, or without consciousness. This is implied by the fact that sensations can be received, and compound movements performed, in the absence of the great nervous centres. Experiments on decapitated frogs yield clear proof that actions of considerable complexity

* Carpenter's *Principles of Comparative Physiology*, p. 665.

may be efficiently executed without the aid of the brain (§ 22). The vivisections of Longet, Vulpian, and others, show that mammals continue to feel and retain certain of their locomotive powers, when both cerebrum and cerebellum have been removed; and that birds similarly deprived of these great cephalic ganglia can still walk about, fly, and even pick up food. Nay, there are cases on record of infants that have for days continued to breathe, cry, suck, and go through various movements, although born without either cerebrum or cerebellum. Apart from evidence of this kind, the personal experiences of every adult demonstrate to him that there are many actions belonging to the psychical division, which either may or may not enter into the mental current. The motion of the legs is necessarily accompanied by various muscular and tactual changes. These, together with the state we call volition, may be distinctly present to consciousness—may be thought of as by a child learning to walk; or they may, as in ordinary walking, be left almost wholly out of consciousness. The processes we perform while eating display a similar relation. The several acts by which each morsel is selected, cut, prepared, and carried to the mouth, may perhaps be held to enter into the current of our thoughts; though in general, and especially during conversation, they obtrude themselves on consciousness very slightly. But many of the impressions and motions involved are next to unconscious. The tactual feelings which the knife-handle gives, the contractions by which it is grasped, and the muscular changes which the arms are every moment undergoing, scarcely at all occupy the attention. So that out of a great number of psychical or *quasi*-psychical actions going on in the organism, only a part are woven into the thread of consciousness; while the others form one or more distinct strands which, as it were, occasionally inosculate with the thread of consciousness.*

* I find that there may sometimes be detected as many as five simultaneous series of nervous changes, which in various degrees rise into con-

So that only by gradual differentiation have the actions constituting psychical life become specially successive, instead of simultaneous and successive; and the distinction is not even now complete. In the lowest types each part of the organism, while it performs by and for itself all other vital functions, also responds by and for itself to external stimuli; and the psychical changes, or what foreshadow them, are both simultaneous and successive to as great an extent as the physical changes. When a nervous system makes its appearance, these incipiently-psychical changes become slightly co-ordinated—have their various strands connected. As the nervous system develops and integrates, the twisting of these various strands of changes into one thread of changes grows more decided. But to the last their union remains imperfect. The vital actions constituting the subject-matter of Psychology, while distinguished from other vital actions by their tendency to assume the form of a single series, never *absolutely* attain that form.

§ 178. This distinction between the psychical and the physical life will be most clearly understood, if we consider the mode in which it first appears and the leading stages of its progress.

Throughout the homogeneous tissue of which the lowest creatures consist, there is complete community of actions. The vital processes go on simultaneously in many places alike. These primordial organisms, if organisms they can be called, exhibit no differentiations of structure or function; and thus the two great divisions of life, equally with the subdivisions of each, are, in the beginning, one.

sciousness so far that we cannot call any of them absolutely unconscious. When walking, there is the locomotive series: there may be, under certain circumstances, a tactual series; there is very often (in myself at least) an auditory series, constituting some melody or fragment of a melody which haunts me; and there is the visual series; all of which, subordinate to the dominant consciousness formed by some train of reflection, are continually crossing it and weaving themselves into it.

The first great differentiation established is that between the inner and outer tissues—the substances of the body and its limiting membrane. The parts of the original protoplasm are subject to but a single contrast of conditions—that between contact with one another, and contact with the environment. The external portions are bathed by the surrounding medium; the internal portions are not. And in response to this primary unlikeness of conditions, there eventually arise unlikenesses of structure and function. That which is permanently outermost takes on the modified form of vital action which its circumstances demand. That which is permanently innermost similarly assumes a more specialized order of activity (*Prin. of Bio.*, § 287).

The division of labour thus commenced may be considered as at first physiological only. In virtue of its position, the surface necessarily monopolizes the duties of absorption—the taking in of water and nutriment and oxygen; while to the included mass remain such duties as its inclusion permits. And when, by involution of the surface, a stomach is formed, the change implies a further separation of duties, such that nutrition is chiefly confined to one part of the limiting membrane and aeration to another. But the advance is not an advance in the physiological division of labour solely. It is at the same time an advance towards the separation of psychical actions from physical ones; and is even a first step towards bringing psychical actions into serial order. Necessarily assuming the vital offices entailed by its externality, the skin also assumes the office of receiving all those impressions which form the raw material of intelligence. The mechanical and other changes going on in the environment, can be responded to by the organism only when it is affected by them; and any change they work in it must be proximately experienced by its surface. The skin, then, being the part immediately subject to the various kinds of external stimuli, necessarily becomes the part in which psychical changes are originated. As contrasted with the contained substance, it comes to be more especially concerned in that adjustment of inner to outer relations which constitutes intelligence. But now mark the implication. The changes constituting the physical life continue to go on simultaneously throughout the entire mass. Those which foreshadow the psychical life are, in an increasing degree, localized on the outside of the mass—belong to its outside primarily and affect some other parts secondarily. Speaking generally, therefore, we may say that while the physical changes are being everywhere initiated throughout a *solid*, the psychical ones, or rather those out of which psychical ones arise, admit of being initiated only on a *surface*. Hence, even by this primary differentiation the incipient psychical life comes to be distinguished from the purely physical life, by the diminished quantity of simultaneous changes it includes.

Subsequent differentiations have like natures and results. This sensitiveness which forms the basis of psychical life, is in the beginning diffused uniformly over the whole surface; but it presently becomes in some degree concentrated. Though, generally, all parts of the skin remain impressible by touch, yet certain parts, having positions which expose them to frequent tactual impressions, become more susceptible than the rest; and in these parts most of the sensations arise. That is to say, the epi-peripheral changes forming the raw material of intelligence, by being restricted in the area of their occurrence, have the characteristic of simultaneity further limited; and the more highly developed the tactual apparatus the more marked is the limitation.

Still greater is this limitation rendered by the evolution of special senses. The olfactory and gustatory sensations are localized in smaller tracts than is the sensation of touch; and each of these tracts is little, if at all, capable of undergoing more than one change at a time. Visual and auditory impressions are receivable only within yet narrower areas; and even the two areas susceptible of each become functionally one. The ears are simultaneously affected by the same sounds; and in the highest creatures the eyes, being so placed as to converge their axes on the same object, yield to consciousness what seems to be one image. Nay, even within each group of visual feelings concentration is manifest. The greatest sensitiveness of the retina is confined to a minute spot; and the feelings initiated in this spot dominate over the others in consciousness. If we add that when the most advanced intelligence is reached, the sensations arising in the nose and the palate are but occasional, while those arising in the eyes and ears are perpetual; it will be seen to what extremely small portions of the organism the changes which form the chief raw materials of intelligence are ultimately confined.

Continued differentiation and integration, thus concentrating the actions out of which psychical life is evolved, first on the surface of the organism, afterwards on certain regions of that surface, afterwards on those most specialized parts of it constituting the organs of the higher senses, and finally in minute parts of these parts, necessarily render the psychical life more and more distinct from the physical life by bringing its changes more and more into serial order. We have nothing to do with the progressive development of the nervous system, and the actions that are carried on throughout its mass. These internal actions are initiated by the external ones to which the senses are subject. And just in proportion as the external ones tend towards the serial form, the consequent internal ones do the same.

§ 179. This growing seriality in the psychical changes is, indeed, necessitated by advance of the correspondence. In other words, the advance of the correspondence, the development of consciousness, and the increasing tendency towards a linear order in the psychical changes, are different aspects of the same progression.

For how only can the constituent changes of any complex correspondence be co-ordinated? Those abilities which an intelligent creature possesses, of recognizing diverse external objects and of adjusting its actions to composite phenomena of various kinds, imply a power of combining many separate impressions. These separate impressions are received by the senses—by different parts of the body. If they go no further than the places at which they are received, they are useless. Or if only some of them are brought into relation with one another, they are useless. That an effectual adjustment may be made, they must be all brought into relation with one another. But this implies some centre of communication common to them all, through which they severally pass; and as they cannot pass through it simultaneously, they must pass through it in succession. So that as the external phenomena responded to become greater in number and more complicated in kind, the variety and rapidity of the changes to which this common centre of communication is subject must increase—there must result an unbroken series of these nervous changes, the subjective face of which is what we call a coherent consciousness.

Of course I do not mean that material actions thus become mental actions. As was said in §§ 41—51, 62, 63, "no effort enables us to assimilate" Mind and Motion. I am merely showing a *parallelism* between a certain physical evolution and the correlative psychical evolution.

§ 180. That mental phenomena constitute a series is a doctrine of old standing, and one the general truth of which none call in question. As we have seen, however, it is to be understood in a qualified sense. When the facts are contemplated objectively, it becomes manifest that though the changes constituting intelligence approach to a single succession, they do not absolutely form one—that there are constantly being performed actions of an intelligent kind which are not present to consciousness—and that, through the many gradations between completely-conscious actions and completely-unconscious ones, the psychical changes merge into those which we distinguish as physical. When we consider the facts subjectively—when we interrogate consciousness, we find that though the general seriality of the changes is obvious, there are many experiences which make us hesitate to assert complete seriality. Let us examine one.

The visual impressions we receive from moment to moment, though ordinarily regarded as single states, are in reality multiple ones; and it becomes a perplexing question how far each of these can be considered a member of a linear series of changes. Besides the particular thing to which the eyes are directed, many other things are partially seen; and no clear separation can be made among the degrees of definiteness with which they are presented to consciousness. Only one point of the object looked at is perceived with perfect distinctness. Yet it cannot be said that consciousness is entirely occupied with this one point; for the object as a whole may be identified by the single glance directed to this one point. Obviously our consciousness of things within the visible area, becomes smaller as they become more remote from the centre to which the axes of the eyes converge. Obviously there is no particular distance from this centre at which we can say that consciousness ceases. And thus there would seem to be a great number of nascent consciousnesses of different intensities existing at the same moment. Only by a certain license, then, can the internal change produced by a visual impression be called single. Strictly speaking, it is a multitude of simultaneous changes bound together. Still more conspicuous becomes the qualification with which we must accept the doctrine that psychical changes are distinguished by their seriality, when, from the state of consciousness produced by a visual impression, we go on to observe the state of consciousness known as the resulting perception. The various distances, solidities, structures, &c., which appear to be immediately given in the impression, being really known by inference, severally imply many changes; and these changes are practically synchronous with those constituting the impression itself, since the positions and natures of the objects are recognized in the instant of perception. So that beyond that complexity of a visual consciousness due to the many co-existing feelings and relations it includes, there is a further complexity caused by the many represented feelings and relations, which are so closely united with the presented ones as seemingly to form with them one consciousness.

Nevertheless, the doctrine that psychical life is distinguished from physical life by consisting of successive changes only, instead of successive and simultaneous changes, may be shown from the very facts here cited. For though a visual impression makes us nascently conscious of many things, yet there is always some one thing of which we are more conscious than of the rest. And when we so look at this one thing as to perceive it in the true sense of the word—to know it as such or such, we are almost exclusively occupied with it. Though the images of other things are all the while being impressed on the retina, and are producing changes there, yet these are not appreciated internally—are scarcely more than physical changes—do not undergo that co-ordination with others which constitutes them psychical changes. And this fact, that in proportion as any object seen is distinctly thought of, the other objects within view cease to be thought of, shows clearly how consciousness becomes more definitely serial as it rises to a higher form. In brief, we may say that while the outer strands of changes which constitute the thread of consciousness, are indefinite and loosely adherent, there is always an internal closely-twisted series of changes, forming what we may consider as consciousness proper.

Psychical changes therefore, if not absolutely distinguished from physical changes by their seriality, are relatively so distinguished; and in proportion as they assume that most developed form constituting rationality they cohere into a seemingly-single succession of states. Though these states are physiologically composite, and were once psychologically composite, yet, to the extent that they have become consolidated elements of thought they may rightly be regarded as severally simple.

§ 181. Such, then, is the outcome of our examination. Gradually differentiated from the lower order of changes constituting bodily life, this higher order of changes constituting mental life assumes a decidedly-serial arrangement in proportion as intelligence advances. Though this serial arrangement never becomes complete, yet in the human consciousness it approaches completeness; and the highest processes of this consciousness are possible only on condition that its successive states, compound as they may be in nature, shall comport themselves as practically elementary. The fact that every proposition expresses a relation, and that every relation subsists between two terms, of itself proves that distinct thought necessitates serial arrangement of its components.

A succession of changes being thus the subject-matter of Psychology, it is the business of Psychology to determine the law of their succession. That they follow one another in a particular way, the existence of Intelligence itself testifies. The problem is to explain their order.

CHAPTER II.

THE LAW OF INTELLIGENCE.

§ 182. All Life, whether physical or psychical, being the combination of changes in correspondence with external co-existences and sequences, it results that if the changes constituting psychical life occur in succession, the law of their succession must be the law of their correspondence.

An adequate statement of this law is by no means easy to find. Did the phenomena in the environment form, like the phenomena of consciousness, a succession, there would be no difficulty. The entire fact would be expressed by saying that the internal succession parallels the external succession. But the environment contains many successions of phenomena, going on simultaneously. Further, there are found in it a great variety of phenomena which are not successive at all, but co-existent. Again, it is unlimited, and the phenomena it includes are not only innumerable, but insensibly pass into a relative non-existence as the distance from the organism increases. Once more, the environment, relatively considered, is ever varying as the organism moves from place to place. How then can the succession of psychical changes be in any way formulated? How is it possible to express the law of a single series of internal phenomena in terms of its correspondence with an infinity of external phenomena, both serial and non-serial, mixed in the most heterogeneous manner, and presented to the moving organism in fortuitous combinations never twice alike?

Were it not that the inner relations *must* correspond with the outer ones; and that therefore the order of states of consciousness *must* be in some way expressible in terms of the external order; we might despair of finding any general law of psychical changes. Even as it is, we may be certain that no general law can apply to extended portions of the series of changes. Mainly dependent as these must be, on the assemblages of things by which the organism is environed, and on the new assemblages perpetually disclosed by its movements, they can be no more formulated than these assemblages can be formulated. Evidently, it is in the immediately-connected changes, and small groups of changes, rather than in the longer concatenations of changes, that a law is to be sought.

§ 183. A correspondence between the internal order and the external order, implies that the relation between any two states of consciousness corresponds with the relation between the two things producing them. How corresponds? The two states of consciousness occur in succession; and all successions are alike in so far as they are simply successions. In what, then, can the correspondence consist? In this, that the *persistence* of the connexion between the states of consciousness is proportionate to the *persistence* of the connexion between the agencies to which they answer. The relations between external objects, attributes, acts, are of all grades, from the necessary to the fortuitous. The relations between the answering states of consciousness must similarly be of all grades, from the necessary to the fortuitous. When any state *a* occurs, the tendency of some other state *d* to follow it, must be strong or weak according to the degree of persistence with which A and D (the objects or attributes that produce *a* and *d*) occur together in the environment. If, in the environment, there is a more persistent occurrence of A with B than of A with D; then, the maintenance of the correspondence implies that when *a* arises in consciousness, *b* shall follow rather than *d*. These are manifest requisites. If the strengths of the connexions between the internal states are not proportionate to the persistences of the relations between the answering external agents, there will be a failure of the correspondence—the inner order will disagree with the outer order.

A due understanding of the matter may best be obtained by examining the several objections to this general statement.

§ 184. The acts of animals exhibit countless failures of the internal order to parallel the external order. In the moth which flies at a candle-flame, there exists no relation of psychical states answering to the relation between light and heat in the environment. The connexion between the odour of a flower and the contained honey, is duly responded to by sequent actions in the moth; as is also the connexion between a certain change in the field of view and the approach of a living body. But there is no internal adjustment by which, after the visual impression produced by a flame, anything like the feeling of a burn is suggested; and hence the creature's death. Again, the birds which on uninhabited islands allow explorers to approach close to them, manifestly lack that co-ordination of psychical changes by which the birds of our woods and moors are led to fly the sportsman. Externally there co-exists with particular appearances, a destructive activity; but internally, the state of consciousness roused by these appearances is not followed by any state of consciousness representing a destructive activity: and a risk of being killed is the consequence. A child's perception of some brightly-coloured berry does not excite an idea of pain, or of the word "poison," but more probably some idea of a pleasant taste; and should injurious chemical properties co-exist with these attractive visible ones, the child's life may be endangered. But in all cases of this kind what is the implication? Do we not speak of the injuries suffered as resulting from lack of sagacity? or as evincing ignorance? And is it not a corollary that, as non-conformity of the inner to the outer order is want of intelligence, conformity of the inner to the outer order is that in which intelligence consists?

A few instances in which the failure of the correspondence is not total but partial, will enforce this conclusion. The dog that comes on hearing his name called, usually does so expecting to find his master or some member of the family; but if, as occasionally happens, his name is called by a stranger, the sequence in his states of consciousness is not adapted to the external facts: he makes a mistake. Among the Australian savages, who mostly meet with violent deaths, it is the belief that any one who dies without apparent cause has been killed by an unseen foe; and a stranger who happens to be found near at hand is liable to be sacrificed as the supposed assassin. Here, though the mental connexion between death and enmity very generally agrees with the connexion in the environment, it by no means uniformly does so. The earlier chemists, by a large number of experiences respecting the combinations of acids and bases, were led to think of substances that neutralized bases as substances having sour tastes; but this relation of ideas, though very generally in harmony with external relations, is not always so.

What, now, do we say of cases like these, in which the inner order does not completely answer to the outer order? We say that they imply a low degree of intellect, or a limited experience, or a but partial enlightenment. And the disappearance of these discrepancies between thoughts and facts we speak of as an advance in intelligence.

§ 185. "But how does this conception include co-existences?" it may be asked. "In so far as the environment presents motions and changes, there is no difficulty in understanding the law of intelligence to be, that the strength of the tendency which the antecedent of any psychical change has to be followed by its consequent, is proportionate to the persistence of the union between the external things they symbolize. But when this union is not between successive things but between simultaneous things —not a union in Time but a union in Space, it is less easy to see how the parallelism between the inner and the outer order can result from fulfilment of this law. The connexion between two states of consciousness occurring in succession, can very well represent the connexion between two external phenomena occurring in succession. But if it can do this, it cannot also represent the connexion between two external phenomena *not* occurring in succession."

The full reply to this objection will be contained by implication in a future chapter, on "The Relations of Co-existence and Non-Coexistence." Here it must suffice to say that the relation of co-existence is distinguished from the relation of sequence by the readiness of its terms to follow one another through consciousness in either order, with equal facility and vividness; that the consciousness of it arises when, in passing backwards and forwards from one term to the other, the sequences being similarly unresisting cancel one another; and that thus it consists of a duplication in consciousness, made up of a sequence and its inversion. Such being the nature of the relation of co-existence, subjectively considered, the law of intelligence as above formulated applies to it no less than to the relation of sequence. If two phenomena, A and B, habitually coexist in the environment, then, when the phenomenon A is presented to the senses, the produced state of consciousness *a*, is immediately succeeded by the state *b*, representing the phenomenon B. The process of thought does not end here, however: if it did, the external relation would be known as a sequence. But the phenomenon B, in the environment, being as much the antecedent of A as A is of B (neither of them being antecedent or consequent, except in the order of our experience of them), it results that the state *b* having been induced, the law involves that it shall be followed by the state *a*. The state *a* again induces the state *b*, and is itself once more re-induced; and so on as long as the relation remains the object of thought. Let us take a case. If the outlines and colours of a body are presented, the resulting consciousness is instantly followed by the consciousness of something resistant; and conversely, if, in the dark, a body is touched, the resulting consciousness is instantly followed by the consciousness of something extended. But in neither case is this all. When the idea of extension has been suggested that of resistance does not finally disappear; nor when the idea of resistance has been suggested does that of extension finally disappear. Both continue to be thought of, as it would seem, almost simultaneously. And since the two terms of the relation cannot be known in absolutely the same state of consciousness; since further, the persistent consciousness of them cannot be one state of consciousness, which is equivalent to no consciousness; it follows that the apparently-incessant presentation of both is really a rapid alternation—an alternation so rapid as to produce the effect of continuity; just as the alternating impressions to which the retina is subjected by the pictures on the opposite sides of a revolving thaumatrope, cause a consciousness of the two pictures as fused into one. Indeed, as this illustration suggests, it is in virtue of the law of intelligence as above formulated, that the relation of co-existence becomes cognizable. For this rapidity with which two states of consciousness answering to two co-existent phenomena, continually reproduce each other, itself exemplifies the extreme cohesion of those internal states which correspond to extremely-coherent external phenomena. And it is in consequence of this extreme cohesion, with the quick alternation involved by it, that the two phenomena are presented apparently together, and the idea of co-existence generated.

Where, as in most cases, there are not two co-existent phenomena but a group, this same law implies cohesion of many different states of consciousness, which similarly produce and re-produce one another in all orders; and such an irregularly-varied presentation and re-presentation of combined properties is just what we know takes place. Even more apparent becomes the conformity of the facts to the law on remembering, that among the clustered states of consciousness those which answer to invariably-coexistent phenomena, as resistance and extension, continue reproducing each other during the whole perception, forming, as it were, the basis of it; whereas the several other states of consciousness answering to the special qualities of the object (qualities not invariably co-existing with resistance and extension) do not remain thus persistent, but appear, and disappear, and reappear in consciousness, with degrees of frequency varying according to the constancy of the answering qualities.

§ 186. A fact seemingly incongruous with the generalization is, that a great proportion of mental changes arise in a way which is in one sense fortuitous. Noises heard through the open window traverse consciousness in a totally-irregular manner. When walking along the streets, the passing people and vehicles produce internal changes of which the succession is indeterminate. External objects, attributes, acts, being infinitely varied in their combinations, every observer is subject to changing assemblages of impressions between which no law of connexion can be traced. Hence, to a large part of the successive changes that constitute intelligence, the formula above given must be inapplicable.

This difficulty will disappear on consideration. The alleged law of intelligence is that the strength of the tendency which the antecedent of any psychical change has to call up its consequent, is proportionate to the persistence of the union between the external things they symbolize. Thus far, we have considered this law with reference to those connexions in consciousness which correspond to established or habitual connexions in the environment. Here the connexions in the environment to which the connexions in consciousness correspond, are accidental ones. A fortuitous relation in the environment is paralleled by a fortuitous relation in thought. Two adjacent mental impressions answer to two phenomena that are by chance adjacent in Space or Time. Thus far the law manifestly applies as before: the internal order conforms to the external order. But how, it may be asked, can the *tendency* of the antecedent state of consciousness to be followed by the consequent state, be described as *proportionate* to the persistence of the *union* between the external things they symbolize? Very properly. Suppose the relation in the environment to be that between a certain person and some unusual place at which he is met. This relation may either be considered generally, in connexion with our experiences at large; or specially, as a particular experience. Generally considered, the relation is one whose terms have no persistence of union whatever: this person may never have been in that place before or since; and in conformity with this absence of persistence in the external union, is the absence of any tendency for the idea of the person and the idea of the place to follow one another—at any rate before he was met there. Specially considered, the relation is one that actually occurred; when it occurred, the union between its terms was absolute; and in conformity with this temporarily-absolute union of its terms, was the temporarily-absolute tendency of the answering states of consciousness to follow one another. As, at the moment it was observed, the adjacent co-existence of the person and the place was as absolute as is the co-existence of extension and resistance in a solid mass; so, at the moment it was observed, the two states of consciousness produced by the person and the place cohered as absolutely as do the conceptions of extension and resistance.

Rightly interpreted then, the law applies as fully to the fortuitous relations presented in any act of perception, as it does to the more or less habitual relations which experience establishes among ideas.

§ 187. In the succession of psychical changes there doubtless occur many combinations which are not easily explicable. Thus, on the case last instanced it may be remarked, that though before a certain person has been met in a certain place, there exists no tendency for the states of consciousness answering to the person and the place to occur together; yet afterwards, the tendency for one of the states to call up the other is often so decided that it shows itself repeatedly. Here then a more persistent relation seems to be established between the states of consciousness than exists between the corresponding phenomena. Sometimes, indeed, the exceptional character of the external relation becomes the very cause of tenacity in the internal relation. The more astonishing the event—the more utterly it is at variance with the ordinary course of things, the stronger becomes the cohesion between the answering states of consciousness. Whence it would appear that, occasionally, psychical changes conform to a law the reverse of that enunciated. Again, it may be asked how, if the law is as alleged, can consciousness ever escape out of certain indissolubly-related states when once it gets into them? If, for instance, the necessary co-existence of extension with a perceived resistance, is known through the rapid alternation of the states of consciousness answering to them; and if these states are as inseparable in the organism as the phenomena in the environment; why should not the two go on reproducing each other for ever?

Fully to answer these and all like queries, would be to include in this chapter an entire system of psychology; for when all peculiarities in the succession of psychical changes are explained, everything is explained. Here, none but general replies can be given. Of these the first is, that, as already said, the law enunciated is the law of intelligence in the abstract; not the law of our intelligence, or of any intelligence with which we are acquainted. It is the law to which psychical changes conform more and more as intelligence becomes higher; but which can be perfectly conformed to only by perfect intelligence. And some of the anomalies pointed out imply nothing beyond imperfection in the conformity. But in the majority of cases it will be found that what seem to be non-conformities are really conformities of a complex kind. It must be remembered that the succession of any one state of consciousness after any other, is due, not to a single tendency, but to a combination of tendencies. As in the environment each phenomena stands related to various surrounding phenomena; as the relations in which it stands to these are some of them necessary, some very general, some special, some purely fortuitous; it is a corollary from the alleged law of intelligence, that each state of consciousness has connexions, more or less close, with many other states—has a number of other states simultaneously tending, with various degrees of strength, to arise after it. Consequently, the change which actually takes place is the *resultant* of many tendencies acting together. The next state of consciousness is produced by composition of forces. The force with which this next state cohered to its immediate antecedent, is aided by the forces with which a group of adjacent states cohered to it; and by the union of many small forces, a compound tendency may be produced which overcomes some single tendency much stronger than any one or two of its components. A great physical law of the external world supplies us with an analogy. Simple as is the principle that every atom of matter gravitates towards every other with a force varying inversely as the square of the distance, yet we see in the still unsolved "problem of three bodies," how complex becomes the effect when several forces conspire and conflict; and we see how, when a number of bodies are acting, the course that will be pursued by any one of them cannot be calculated. Similarly, though the law of attraction of mental states is simple; yet when the attractions of many mental states come into play—some uniting, some conflicting—it becomes next to impossible to predict the result. And just as in the ascent of a balloon we may meet with a phenomenon seemingly quite at variance with the law of gravitation, though really quite in harmony with it; so there may occur mental changes which, while they appear to be directly opposed to the law of psychical succession, are nevertheless fulfilments of it.

Apparent anomalies are thus reconcilable with the conclusion, that the strength of the tendency which the antecedent of any psychical change has to be followed by its consequent, is proportionate to the persistence of the union between the external things they symbolize. Such is the *à priori* necessity; and such is the generalization reached *à posteriori*. Only in virtue of this law can there be that adjustment of internal relations to external relations which constitutes life, while it makes possible the continuance of life. And only by supposing such a law to exist can we explain the facts, that relations which are absolute in the environment are absolute in us, that relations which are probable in the environment are probable in us, that relations which are fortuitous in the environment are fortuitous in us.

CHAPTER III.

THE GROWTH OF INTELLIGENCE.

§ 188. The law enunciated in the foregoing chapter, being the law of Intelligence in the abstract—the law which Intelligence fulfils more and more the further it advances, we have next to examine the modes in which better fulfilment of the law is exhibited; and to seek the general cause for this ever-increasing fulfilment of it.

Three ways in which progress shows itself may be distinguished. There is, first—increase in the *accuracy* with which the inner tendencies are proportioned to the outer persistences. There is, second—increase in the *number* of cases, unlike as to kind but like as to grade of complexity, in which there are inner tendencies answering to outer persistences. And there is, third—increase in the *complexity* of the coherent states of consciousness, answering to coherent complexities in the environment. The organism is placed amid innumerable relations of all orders. It begins by imperfectly adjusting its actions to a few of the simplest of these. To adjust its actions more exactly to these few simplest, is one form of advance. To adjust its actions to a greater variety of these simplest, is a further form of advance. To adjust its actions to successive grades of the more complicated, is yet another form of advance. And to whatever stage it reaches there are still the same three kinds of improvement open to it—a perfecting of the correspondences already achieved; an achievement of other correspondences of the same order; and an achievement of correspondences of a higher order: all of them implying greater fulfilment of the law of intelligence.

But now, what are the requisites to this progress? Is the genesis of Intelligence explicable on any one general principle applying at once to all these modes of advance? If so, what is this general principle?

§ 189. In the environment there exist relations of all orders of persistence, from the absolute to the fortuitous. Consequently, in a creature displaying a developed correspondence, there must exist all grades of strength in the connexions between states of consciousness. As a high intelligence is only thus possible, it is manifestly a condition to intelligence in general that the antecedents and consequents of psychical changes shall admit of all degrees of cohesion. And the question to be answered is:—How are their various degrees of cohesion adjusted?

Concerning their adjustments there are two possible hypotheses, of which all other hypotheses can be but modifications. On the one hand, it may be asserted that the strength of the tendency which each state of consciousness has to follow any other, is fixed beforehand by a Creator—that there is a "pre-established harmony" between the inner and outer relations. On the other hand, it may be asserted that the strength of the tendency which each state of consciousness has to follow any other, depends on the frequency with which the two have been connected in experience—that the harmony between the inner and outer relations arises from the fact that the outer relations produce the inner relations. Let us briefly examine these two hypotheses.

For the first the reason given, like the reason given for the special-creation hypothesis at large, is that certain of the phenomena cannot otherwise be explained. This supernatural genesis of the adjustment is alleged because no natural genesis has been assigned. The hypothesis has not a single fact to rest on. The facts that may be cited in its support, such as those of reflex action, are simply facts which have not yet been explained; and this alleged explanation of them as due to a pre-established harmony, is simply a disguised mode of shelving them as inexplicable. A further criticism is, that those who espouse this theory dare not apply it beyond a narrow range of cases. It is only where the connexions between psychical states are absolute—as in the so-called forms of thought and in the congenital instincts—that they fall back on "pre-established harmony." But they should either go the entire length with Leibnitz, or not go with him at all. If they assume that the adjustment of inner relations to outer relations has been in some cases fixed beforehand, they ought in consistency to assume that it has been in all cases fixed beforehand. If, answering to each absolutely-persistent connexion of phenomena in the environment, there has been provided some absolutely-persistent connexion between states of consciousness; why, where the outer connexion is almost absolutely persistent, and the inner connexion proportionately persistent, must we not suppose a special provision here also? why must we not suppose special provisions for all the infinitely-varied degrees of persistence? The unqualified adoption of the hypothesis is, however, declined, for obvious reasons. It would involve the assertion of a rigorous necessity in all thought and action—an assertion which those who favour this hypothesis are, more than any others, disinclined to make. It would raise the awkward question why at birth there is not as great a power of thinking, and of thinking correctly, as at any subsequent period. It would imply that men are equally wise concerning things of which they have had no experience, as concerning things of which they have had experience. It would altogether negative that advance in enlightenment which characterizes human progression. In short, not only is the hypothesis without foundation in our knowledge of mental phenomena; but acceptance of it would necessitate rejection of all such knowledge of mental phenomena as we have acquired.

Contrariwise, for the second hypothesis the evidence is overwhelming. The multitudinous facts commonly cited to illustrate the doctrine of association of ideas, support it. It is in harmony with the general truth that from the ignorance of the infant the ascent is by slow steps to the knowledge of the adult. All theories and all methods of education take it for granted—are alike based on the belief that the more frequently states of consciousness are made to follow one another in a certain order, the stronger becomes their tendency to suggest one another in that order. The sayings—" Practice makes perfect," and " Habit is second nature," remind us how long-established and universal is the conviction that such a law exists. Exemplification of it is furnished by the fact that men who, from being differently circumstanced, have had different experiences, reach different generalizations; and by the fact that a wrong conception will become as firmly established as a right one, if the external relation to which it answers has been as often repeated. It is in harmony with these among other familiar truths;—that phenomena wholly unrelated in our experience, we have no tendency to think of together; that where a certain phenomenon has occurred in many relations, we usually imagine it as recurring in the relation in which it has most frequently occurred; that when we have witnessed many recurrences of a certain relation we come to have a strong belief in that relation; that if a relation has been daily experienced throughout life with scarcely an exception, it becomes difficult for us to conceive it as otherwise—to break the connexion between the states of consciousness representing it; and that where a relation has been perpetually repeated in our experience with absolute uniformity, we are entirely disabled from conceiving the negation of it.

The only orders of psychical sequences not obviously included by this general law, are those classed as reflex and instinctive—those which are apparently established before any experience has been had. But it is possible that, rightly interpreted, the law covers these also. Though reflex and instinctive sequences are not determined by the experiences of the *individual* organism manifesting them; yet the experiences of the *race* of organisms forming its ancestry may have determined them. Hereditary transmission applies to psychical peculiarities as well as to physical peculiarities. While the modified bodily structure produced by new habits of life is bequeathed to future generations, the modified nervous tendencies produced by such new habits of life are also bequeathed; and if the new habits of life become permanent the tendencies become permanent. Let us glance at the facts.

Among the families of a civilized society, the changes of occupation and habit from generation to generation and the intermarriage of families having different occupations and habits, greatly confuse the evidence of psychical heredity. But it needs only to contrast national characters to see that mental peculiarities caused by habit become hereditary. We know that there are warlike, peaceful, nomadic, maritime, hunting, commercial, races—races that are independent or slavish, active or slothful; we know that many of these, if not all, have a common origin; and hence it is inferable that these varieties of disposition, which have evident relations to modes of life, have been gradually produced in the course of generations. The tendencies to certain combinations of psychical changes have become organic. In domesticated animals parallel facts are familiar. Not only the forms and constitutions, but the dispositions and instincts of horses, oxen, sheep, pigs, fowls, have become different from those of their wild kindred. The various breeds of dogs exhibit numerous varieties of mental character and faculty permanently established by mode of life; and their several tendencies are spontaneously manifested. A young pointer will point at a covey the first time he is taken afield. A retriever brought up abroad has been remarked to fulfil his duty without instruction. In such cases there is evidently a bequeathed tendency for the psychical changes to take place in a special way.* Even from the conduct of untamed creatures we may gather evidence having like implications. The birds of inhabited countries are far more difficult to approach than those of uninhabited ones. And the manifest inference is, that continued experience of human enmity has wrought organic changes in them—has modified their instincts—has altered the connexions among their psychical states.†

Of the two hypotheses, then, the first is supported by no positive evidence whatever, while the second is supported by such positive evidence as we have. That the inner co-

* Had Mr. Darwin's *Origin of Species*, been published before I wrote this paragraph, I should, no doubt, have so qualified my words as to recognize "selection," natural or artificial, as a factor. Being written, however, I prefer to let the passage remain with nothing beyond verbal changes, and to make the needful qualification in a note. I do this partly to avoid an inconvenient complication of the statement. But my chief reason is that, while holding survival of the fittest to be always a co-operating cause, I believe that in cases like these it is not the chief cause. The reasons for this belief are given in the *Principles of Biology*, § 166.

† I was somewhat surprised when a very competent critic called in question this modification of instincts in birds; and failing to remember on what authority I had alleged the fact (which I supposed to be well known) I was unable to justify myself. An American friend, who was present, has since been so good as to forward me a verification, in the form of an incidental remark contained in a letter from Captain William Reynolds, of the United States Navy. This letter (the original is before me) is written from Brook's Island, described by Captain Reynolds as a "little *midge* of sand in the midst of the wide Pacific." After giving other particulars of this uninhabited island, he says:—"The birds won't get out of the way of our people when we land, but show fight and have to be kept off with sticks. During this *mêlée*, the tropic birds lose their tail feathers, which are plucked from them, as you would pull a blade of grass, while walking over a field."

hesions of psychical states are pre-adjusted to the outer persistences of the relations symbolized, is a supposition which, if taken literally, involves absurdities so great that none now make it in respect of any cohesions save the congenital. That it is the true supposition in so far as this limited range of cases is concerned, no evidence can be given; since only to one present at the creation of an organism is knowledge of pre-adjustment possible. So far as the facts are accessible, the supposition is wholly at variance with them; and it is entertained only where it cannot be brought face to face with the facts. On the other hand, the supposition that the inner cohesions are adjusted to the outer persistences by accumulated experience of those outer persistences, is in harmony with all our actual knowledge of mental phenomena. Though in so far as reflex actions and instincts are concerned, the experience-hypothesis seems insufficient; yet, its seeming insufficiency occurs only where the evidence is beyond our reach. Nay, even here, such few facts as we can get point to the conclusion that automatic psychical connexions result from the registration of experiences continued for numberless generations.

In brief, the case stands thus:—It is agreed that all psychical relations save the absolutely indissoluble are determined by experiences. Their various strengths are admitted, other things equal, to be proportionate to the multiplication of experiences. It is an unavoidable corollary that an infinity of experiences will produce a psychical relation that is indissoluble. Though such infinity of experiences cannot be received by a single individual, yet it may be received by the succession of individuals forming a race. And if there is a transmission of induced tendencies in the nervous system, it is inferable that all psychical relations whatever, from the necessary to the fortuitous, result from the experiences of the corresponding external relations; and are so brought into harmony with them.

Hence the growth of intelligence at large depends on the law, that when any two psychical states occur in immediate succession, an effect is produced such that if the first subsequently recurs there is a certain tendency for the second to follow it.

§ 190. By this law, if it is the true one, must be interpretable all the phenomena, from their lowest to their highest grades. Let us first observe how far the leading deductions agree with the leading facts.

A manifest corollary from the law is that the psychical relations in any organism, will correspond best to those physical relations it comes most in contact with. The environment in general is infinite. The environment of each order of creature is practically more or less limited. And each order of creature has an environment which, besides being limited, is practically more or less special. The law implies, then, that the psychical relations displayed by each order of creature, will be those which recur the oftenest within the range of its experience. And we know the fact to be that they are so.

Contemplating the animal kingdom at large, the first psychical relations established ought to be those answering to the most prevalent environing relations of the simplest kind. Such are just what we find. The stationary polype with outstretched tentacles, contracts on being touched. Now a creature that is not itself moving can be touched only by something in motion. And this universal relation between collision and some moving body, is one of the first to be responded to. When a shadow passing across a rudimentary eye is followed by a movement in the creature possessing that eye, the internal relation between the impression and the motion corresponds with the relation between a passing opacity and a passing solidity in the environment; and this is one of the most general relations. Various analogous cases will suggest themselves.

In the progress of life at large, as in the progress of the individual, the adjustment of inner tendencies to outer persistences, must begin with the simple and advance to the complex; seeing that both within and without, complex relations, being made up of simple ones, cannot be established before simple ones have been established. After experience of some persistent relation A to B in the environment has generated a persistent relation between the answering psychical states *a* and *b*; and after some other persistent outer relation C to D, has similarly generated a persistent inner relation *c* to *d*; then, if in the environment there exists any relation between the relations A to B and C to D, it becomes possible for repeated experiences to generate in the organism a relation between *a* to *b* and *c* to *d*. But it is manifestly impossible for this to be done until the relations *a* to *b* and *c* to *d* have been themselves generated. This deduction, too, we see to be in complete conformity with the facts, both of individual evolution and of general evolution.

Further, it must follow that the only thing required for the establishment of a new internal relation answering to a new external one, is, that the organism shall be sufficiently developed to cognize the two terms of the new relation, and that being thus developed, it shall be placed in circumstances which present the new relation. Here also, there is harmony between the *à priori* inference and the inference from observation. In our domestic animals there are constantly formed new psychical relations answering to such new physical relations as have terms sufficiently simple to be perceived. And in human civilization we see the truth illustrated in the progress to wider and wider generalizations.

But the validity of these several corollaries will become more apparent as we proceed. Let us now pass on to contemplate the growth of Intelligence under its leading aspects.

CHAPTER IV.

REFLEX ACTION.

§ 191. Under its simplest form, Reflex Action is the sequence of a single contraction upon a single irritation. A vague manifestation of this sequence marks the dawn of sensitive life; and, indeed, it is chiefly because they shrink on being touched, that many of the simpler animals are recognized as living.

But though in the movements of Zoophytes it is foreshadowed, Reflex action proper is exhibited only when we ascend to creatures in which there exist nerves and muscles. In such creatures, the response is effected not through the agency of the one uniform tissue constituting the body, which is at once irritable and contractile; but the irritability is confined to one specialized structure, while the contractility is confined to another specialized structure; and the two structures are placed in such relation that irritation of the one is followed by contraction of the other. Some impression is made on the peripheral termination of a nerve; the molecular motion it sets up is propagated along the nerve until it reaches a ganglion; the large quantity of molecular motion there disengaged, discharges itself along another nerve proceeding from the ganglion to a muscle; and thus the stimulus carried through an afferent nerve to some *libero-motor* centre, is thence *reflected* in multiplied amount through an efferent nerve to the contractile agent.

In this simplest form of psychical action we see a single internal relation adjusted to a single external relation. Any one of the suckers on the arm of a cuttle-fish that has been separated from the body, will, under the influence of its own independent ganglion, attach itself to a substance placed in contact with it—the established relation between the tactual and muscular changes in the sucker and its ganglion, is parallel to the uniform relation between resistance and extension in its environment—the inner cohesion of psychical states is as persistent as is the outer relation between attributes. And if we remember that in the actions of the cuttle-fish this inner relation is perpetually being repeated in response to the outer relation, we see how the organization of it in the species answers to the infinitude of experiences received by the species.

§ 192. Reflex action being the lowest form of psychical life, is, by implication, most nearly related to physical life: in it we see the incipient differentiation of the two. This truth may be discerned from several points of view.

It was shown that the contraction which occurs in a polype when touched, or otherwise stimulated, probably results from the increased vital change which the stimulus produces in the disturbed tissues (§ 140); and though one of these reflex actions, as of a cephalopod's sucker, is effected in a more definite and more complicated way, yet it does not so far differ as to be removable from the class of physical actions. Mostly, it would be considered as a misuse of words to call it psychical. So that while as belonging to the order of vital changes which, in their higher complications, we dignify as psychical, it may be convenient to classify it as psychical; yet it must be admitted that in position it is transitional. Again, in well-organized creatures, the physical life is itself regulated by reflex actions. Those rhythmical movements of the alimentary canal which follow the introduction of food, are of reflex origin; as are also those processes by which, under the same stimulus, the digestive fluids are prepared and poured out. The various viscera, too, performing each its separate function, must have their relative activities adjusted; and the due balancing of them is effected by reflex action. It is held that the changes in the state of each viscus are impressed on the nerves proceeding to ganglia in the sympathetic, whence they are reflected to the other viscera; so that, for instance, when the stomach has been filled, the stimulus it diffuses through this channel to the heart and lungs, causes them to send it an increased quantity of aërated blood. In yet another respect may we see a close alliance between the physical life and this nascent psychical life. As was shown in a foregoing chapter, the psychical life is broadly distinguished from the physical life by the peculiarity that its changes, instead of being simultaneous and successive, are successive only; but, as was also shown, this peculiarity makes its appearance gradually, and becomes marked only when the psychical life becomes high. Now the reflex actions in which the nascent psychical life is seen, are nearly as much characterized by simultaneity as are the purely physical actions. A great number of these simplest nervous changes go on quite independently in the same organism at the same moment. Once more, the proximity of these reflex actions to the physical life is implied by their unconsciousness. Not only in co-ordinating the visceral processes, but also in co-ordinating the processes of perception, there constantly go on reflex actions of which we have no immediate knowledge; as those by which the focus of each eye is adjusted to distances and the closure of the iris adapted to the quantity of light. Other reflex actions of which we can take direct cognizance—as that of breathing—can go on without our thinking of them. And others which are commonly accompanied by local sensation—as when the foot is withdrawn from something which tickles it—are found to be most energetically performed when, from some spinal lesion, local sensation has been abolished. Remembering how nearly unconscious our own locomotive actions become when we are absorbed in thought, it is inferable that in creatures whose reflex locomotive actions are congenitally perfect, they are quite unconscious. The rapid alternations of a centipede's leg or a fly's wing, are probably as automatic as are those of a steam-engine piston; and may be co-ordinated after a generally analogous manner. Just as, in a steam-engine, the arrival of the piston at a certain point is necessarily accompanied by the opening of a valve serving to admit the steam which will drive the piston in the reverse direction; so, in one of these rhythmically-moving organs, the performance of each motion ends in bringing the organ to a position in which the stimulus to an opposite motion acts upon it.

But though, from all points of view, Reflex action is seen to be a species of change very little removed from the physical changes constituting vegetative life; yet even in it we may discern a fulfilment of the primordial conditions to consciousness. In the lowest conceivable type of consciousness—that produced by the alternation of two states—there are involved the relations constituting the forms of all thought. And such an alternation of two states is just that which occurs in the ganglion connected with one of these rhythmically-moving organs.

§ 193. From that lowest kind of Reflex action in which a single impression produces a single contraction, the ascent is to complications in the stimuli and in the acts resulting from them. There is no precise distinction between a single contraction and a combination of contractions. From the excitation of dispersed muscular fibres to the excitation of fibres aggregated into definite bundles, the transition is insensible; and there is similarly a gradual passage from single contractions to combinations of contractions. Hence, under the head of Reflex action there are classed numerous cases in which a whole group of muscular motions results from one impression. The decapitated frog which leaps when one of its feet is irritated, supplies an illustration. To examine the varieties and complexities of Reflex action, is the task of the physiologist rather than of the psychologist. Here it concerns us merely to note the bearing of the phenomena on the general argument.

We have to observe that these simplest of psychical changes correspond to external relations which are only one degree more specialized than the relations to which physical changes correspond. While the processes of the purely vegetative life are in adjustment with those most general relations between nutriment, oxygen, temperature, moisture, light, which pervade the environment at large; these lowest processes of the animal life are in adjustment with the most general relations of the solid bodies contained in the environment: as those between tangibility and solidity, motion and life.

Further, it is to be noticed that in conformity with the general law of intelligence, we have, in one of these reflex actions, an established connexion between two psychical states answering to an established connexion between two external phenomena. Not that the inner tendency is exactly proportionate to the outer persistency. In many cases it is absolute in the organism though by no means absolute in the environment. And this is just what is to be looked for among these manifestations of nascent intelligence; since the adjustment of the inner tendencies to the outer persistencies, being the law of intelligence in the abstract, cannot be fulfilled where the intelligence is incipient.

Lastly may be named the fact, that these indissolubly-connected psychical states exist where there are perpetually-repeated experiences of the external relations to which they answer.

CHAPTER V.

INSTINCT.

§ 194. Not using the word as the vulgar do, to designate all other kinds of intelligence than the human, but restricting it to its proper signification, Instinct may be described as—compound reflex action. I say described rather than defined, since no clear line of demarkation can be drawn between it and simple reflex action. As remarked in the last section, the *dirigo-motor* processes which reflex actions show us, pass by degrees from the simple to the complex; and a cursory inspection of the facts shows us that the *recipio-motor* processes do the like. Nevertheless we may conveniently distinguish, as a higher order of these automatic nervous adjustments, those in which complex stimuli produce complex movements.

That the propriety of thus marking off Instinct from primitive reflex action may be clearly seen, let us take examples. "A fly-catcher," says Dr. Carpenter, "immediately after its exit from the egg, has been known to peck at and capture an insect—an action which requires a very exact appreciation of distance, as well as a power of precisely regulating the muscular movements in accordance with it." Now this action, which is proved by the circumstances to be purely automatic, implies the combination of many stimuli. The excitation of certain retinal nerve-fibres must be one—an excitation which is itself a somewhat special combination of excitations. Another component in the general stimulus must be that proceeding from the muscles by which the eyes are directed. And yet another component must be that proceeding from the muscles which alter the focal adjustments of the eyes. Without impressions proceeding from both these sets of muscles, it would be impossible for the head to be guided in the right direction, or for the beak to be closed at the right moment. Thus the action implies impressions on retinal nerves, impressions on nerves proceeding from muscles which move the eyes, and impressions on nerves proceeding from muscles which adjust their lenses—implies that all these nerves are excited simultaneously in special ways and degrees; and that the complex co-ordination of muscular contractions by which the fly is caught, is the result of this complex co-ordination of stimuli. Of such co-ordinated acts automatically resulting from co-ordinated stimuli, we have many illustrations in ourselves. Though originating in volition, our ordinary movements are performed in a mode just like that described. When putting out the hand to grasp an object before us, we are unconscious of the particular muscular adjustments made. We see the object, and in response to the wish for it the arm is moved in a fit way. But were any of the various nervous stimuli involved in the perception absent, the arm would not be guided aright. That is to say, the special muscular co-ordination is due to the special co-ordination of sensations received from the eye and its adjuncts: volition being concerned merely in setting the process going. One of these actions of our own differs from that of the newly-hatched fly-catcher mainly in this, that whereas, in ourselves, the impressions and motions, being almost infinitely varied and severally repeated with comparative infrequency, are not congenitally co-ordinated but are co-ordinated in the course of our first years; in the fly-catcher, descended from a race in which a special combination is perpetually repeated by every individual throughout life, this combination is ready-organized.

So that while in the primitive forms of reflex action a single impression is followed by a single contraction; while in the more developed forms of reflex action a single impression is followed by a combination of contractions; in this which we distinguished as Instinct, a combination of impressions is followed by a combination of contractions; and the higher the Instinct the more complex are both the directive and executive co-ordinations. Carrying with us this conception, let us now contemplate the facts in connexion with the general laws we are tracing out.

§ 195. Instinct is obviously further removed from purely physical life than is simple reflex action. While simple reflex action is common to the internal visceral processes and to the processes of external adjustment, Instinct is not. There are no instincts displayed by the kidneys, the lungs, the liver: they occur only among the actions of that nervo-muscular apparatus which is the agent of psychical life.

Again, the co-ordination of many stimuli into one stimulus is, so far as it goes, a reduction of diffused simultaneous changes into concentrated serial changes. Whether the combined nervous acts which take place when the fly-catcher seizes an insect, are regarded as a series passing through its centre of co-ordination in rapid succession, or as consolidated into two successive states of its centre of co-ordination, it is equally clear that the changes going on in its centre of co-ordination have a much more decided linear arrangement than have the changes going on in the scattered ganglia of a centipede.

In its higher forms, Instinct is probably accompanied by a rudimentary consciousness. There cannot be co-ordination of many stimuli without some ganglion through which they are all brought into relation. In the process of bringing them into relation, this ganglion must be subject to the influence of each—must undergo many changes. And the quick succession of changes in a ganglion, implying as it does perpetual experiences of differences and likenesses, constitutes the raw material of consciousness. The implication is that as fast as Instinct is developed, some kind of consciousness becomes nascent.

Further, the instinctive actions are more removed from the actions of simple bodily life in this, that they answer to external phenomena which are more complex and more special. While the purely physical processes going on throughout the organism respond to those most general relations common to the environment as a whole; while the simple reflex actions respond to some of the general relations common to the individual objects it contains; these compound reflex actions which we class as instincts, respond to those more involved relations which characterize certain orders of objects and actions as distinguished from others.

Greater differentiation of the psychical life from the physical life is thus shown in several ways—in the growing distinction between the action of the vegetative and animal systems; in the increasing seriality of the changes in the animal system; in the consequent rise of incipient consciousness; and in the higher speciality of the outer relations to which inner relations are adjusted: which last is indeed the essence of the advance, to which the others are necessary accompaniments.

§ 196. We are now prepared to inquire how, by accumulated experiences, compound reflex actions may be developed out of simple ones.

Let us begin with some low aquatic creature possessing rudimentary eyes. Sensitive as such eyes are only to marked changes in the quantity of light, they can be affected by opaque bodies moving in the surrounding water, only when such bodies approach close to them. But bodies carried by their motion very near to the organism, will, by their further motion, be brought in contact with it. The cases in which an external object passes by almost at a tangent to that part of the organism where the rudimentary eye is placed, so as nearly to touch the surface but not quite, must be exceptional. In its earliest forms sight is, as before said, little more than anticipatory touch (§ 142): visual impressions are habitually followed by tactual ones. But tactual impressions are, in all these creatures, habitually followed by contractions—contractions which, as was pointed out in § 140, are probably the necessary effects of mechanically accelerating the vital changes—contractions which, under like stimuli, occur even in certain plants, and are so shown to be producible by alterations in the processes of purely physical life. Result as they may, however, it is beyond question that from the zoophytes upwards, touch and contraction form an habitual sequence; and hence, in creatures whose incipient vision amounts to little more than anticipatory touch, there constantly occurs the succession —a visual impression, a tactual impression, a contraction. Now the evolution of a nervous system is a necessary concomitant of that specialization which originates the senses. On the one hand, until the general sensitiveness is in some degree localized, the internuncial function of the nervous system cannot exist; and on the other hand, no such localized sensitiveness can exist without something in the shape of nerves. A nascent sense of sight, therefore, implies a nascent nervous communication. And along with a nascent nervous communication we may see the first illustration of the growth of intelligence. If psychical states (using the term in its widest sense) which follow one another time after time in a certain order, become every time more closely connected in this order, so as eventually to become inseparable; then it must happen that if, in the experience of any species, a visual impression, a tactual impression, and a contraction, are continually repeated in this succession, the several nervous states produced will become so consolidated that the first cannot be caused without the others following —the visual impression will be instantly succeeded by a nervous excitation like that which a tactual impression produces, and this will be instantly succeeded by a contraction. There will thus occur a contraction in anticipation of touch.

What must result from a further development of vision? Evidently the same bodies will be discerned at greater distances, and smaller bodies will be discerned when close to. Both of these must produce obscurations which are faint in comparison with that obscuration produced by a large body about to strike the creature's surface. But now mark the accompanying experience. A faint obscuration will not, like an extreme one, be habitually followed by a strong tactual impression and a subsequent contraction. If caused by a great mass passing at some distance, there will probably be no collision—no tactual impression at all. If caused by a little mass which is very near, the collision that follows will be comparatively slight—so slight as not to excite a violent contraction, but only such tension in the muscular apparatus as is seen in any creature about to seize upon prey. This is by no means an assumption. Among animals in general, ourselves included, a nervous impression which, if slight, simply rouses attention and braces up the muscles, causes convulsive contortions if intense. It is therefore a deduction from a well-established law of the nervo-muscular system, that a creature possessing this somewhat improved vision will, by a partial obscuration of light, have its muscles brought into a state of partial tension—a state fitting them either for the seizure of a small animal should the partial obscuration be caused by the impending collision of one, or for sudden retreat into a shell should the obscuration be increased by the near approach of a larger animal. So that even from this simple advance there arises a somewhat great speciality and complexity in the inner relations answering to outer relations.

Instead of a stationary creature, suppose the creature contemplated to be one that habitually moves about in the water; and suppose a further development of the eyes—a development consisting in enlargement of each retina, and subdivision of it into separate sensitive agents. In such a creature, the eyes are subject to perpetually-changing impressions produced by the objects amid which it swims. These impressions fall on different parts of its retinæ, according to the positions of the objects making them. Laterally-placed bodies either affect one retina only, or one much more than the other. Bodies above have their images cast on the lower parts of its retinæ. Bodies below, if visible at all, cast images on their upper parts. Of the impressions thus made, however, few are directly followed by tactual impressions: the creature's forward movement carries it away from the objects making them. Only when the impression made by a lateral object is both very strong and changes very rapidly—only when it is the impression produced by an approaching larger animal, will there result any motor excitation. Faint and slowly-changing lateral impressions, not being habitually followed by tactual impressions, will not affect the actions. But now mark that there are certain visual impressions which, though not strong, are habitually followed by tactual ones of a particular kind. I refer to the visual impressions made by small objects in front. When, during the creature's passage through the water, certain parts of its two retinæ are simultaneously affected by impressions of moderate strength; it commonly happens that immediately afterwards, the feelers and head come in contact with something serving for food. A visual impression of a special kind, is followed by a tactual impression on the prehensile organs; and, consequently, by all those muscular actions which the presentation of food to them calls forth. The often-recurring succession will be this:—Slight excitation of a particular double group of retinal nerves; excitation of the nerves of the prehensile organs; excitation of a special set of muscles. And these three psychical states being habitually connected, must, by repetition in countless generations, become so coherent that the special visual impression will directly call forth the muscular actions by which prey is seized. Eventually, the sight of a small object in front will cause the various motions requisite for the capture of prey.

Here, then, we see how one of the simpler instincts will, under the requisite conditions, be established by accumulated experiences. Let it be granted that the more frequently psychical states occur in a certain order, the stronger becomes their tendency to cohere in that order, until they at last become inseparable; let it be granted that this tendency is, in however slight a degree, inherited, so that if the experiences remain the same each successive generation bequeaths a somewhat increased tendency; and it follows that, in cases like the one described, there must eventually result an automatic connexion of nervous actions, corresponding to the external relations perpetually experienced. Similarly if, from some change in the environment of any species, its members are frequently brought in contact with a relation having terms a little more involved; if the organization of the species is so far developed as to be impressible by these terms in close succession; then, an inner relation corresponding to this new outer relation will gradually be formed, and will in the end become organic. And so on in subsequent stages of progress.

This of course is intended merely as a rude indication of the mode in which the general principles enunciated explain the development of instincts. The law of intelligence being that the strengths of the inner cohesions between psychical states must be proportionate to the persistences of the outer relations symbolized; and the development of intelligence in conformity with this law being, in all cases of which we have direct knowledge, secured by the one simple principle that experience of the outer relations produces the inner cohesions and makes the inner cohesions strong in proportion as the outer relations are persistent; it was requisite to inquire whether the intelligence concerning whose genesis we have no direct knowledge, had probably a like origin. And reasoning deductively from the conditions of the case, we conclude that this same simple principle is sufficient to account for the facts—or rather, for a type of them. To trace out the actual development of instincts, in their infinite varieties and complications, must ever remain impossible: adequate data are not to be had. The foregoing is to be taken simply as an adumbration of the probable mode of development.

§ 197. What must be the ulterior results of this mode of development? Assuming some such process as that above suggested to be the one by which instincts in general are evolved; let us deduce the characteristics of the evolution regarded in its ensemble, and see how far they agree with the actual characteristics.

The progression from the lower to the higher instincts is, throughout, a progression towards greater speciality and complexity of correspondence. The movement produced in a creature having a rudimentary eye, when an opaque object is suddenly passed before that eye, is more general and more simple than is the movement produced in a creature which grasps the prey passing before it. In the first case the effect is produced whatever the relative position of the object, providing the obscuration be considerable; in the second case it is produced only when the object is just in front. To the outer relation between a moving opacity and a living solid body, is now added a relation of position; and not only a relation of position but one of magnitude, since the effect is not the same when a large as when a small body is presented. That is to say, the external phenomenon responded to is a co-ordinated group of attributes and relations; while internally, there is a co-ordinated group of changes—not a single impression and a single motion, but at least a pair of impressions and a considerable complication of motions. The correspondence is alike more complex and more special.

Now, that the evolution of intelligence, if caused by the multiplication of experiences, must follow this order, is demonstrable *à priori*. Phenomena become less frequent in proportion as they become more complex; and hence, the experiences of them can never be so numerous as are the experiences of simple phenomena. The relation between a passing obscuration and a living body, recurs oftener than the relation between a certain degree of obscuration and danger, or than the relation between a certain other degree of obscuration and food. Again, each of these relations is more general than the relation between a particular size and form of visual impression and an object of a particular class. And again, this relation is more general than that between a particular size, form, and colour of visual impression, and a certain species of that class. The inevitable corollary is, that if inner relations are moulded to outer relations by the accumulation of experiences, the simpler must be established before the more complex.

The necessity of this order will be still better seen on remembering that complex relations, both external and internal, being composed of simple ones, must be preceded by simple ones. Before there can exist the objective relations implied in the action of one body on another, there must exist the objective relations implied in the existence of each body. And similarly, before complex subjective relations can be established there must have been established the simpler subjective relations they are composed of.

Observing that this inference from the experience-hypothesis harmonizes with the facts, so far as they are accessible to us, let us go on to observe some important corollaries.

§ 198. If simple and general relations in the environment must be those most frequently experienced, and those to which the response first becomes decided; if environing relations a grade less simple and general are thus rendered appreciable, and by a repeated, though a less-frequently repeated, experience, also establish answering internal relations; and if this process slowly extends to relations successively more complex and special, and less frequent; then there will ultimately be established in the organism, numerous psychical relations having different degrees of cohesion. While an infinity of experiences will have rendered the first and simplest of these psychical relations indissoluble; while experiences extremely numerous, though less numerous, may have given indissolubleness to psychical relations one degree more complex or two degrees more complex or three degrees more complex; it is manifest that among relations increasingly involved and decreasingly frequent, there must come a stage at which the answering psychical relations are not indissoluble. This may be conveniently illustrated by symbols.

Let A and B represent two attributes of matter in general —say extension and resistance—to the constant relation between which a responsive relation has been established in the organism. Let C and D be two extremely general attributes of animal matter—say motion and life—to which also there is a responsive internal relation. It will be at once understood that experiences of the united group of attributes A, B, C, D, recurring as they do in every living creature met with, may eventually establish an answering connexion of internal relations that is practically as absolute as the original ones. It is also comprehensible that if the creatures serving for prey are below a certain size, L, while those found to be enemies are mostly of a much greater size, M; continued experience may establish different organic responses to the different groups of co-existent attributes, A, B, C, D, L, and A, B, C, D, M. And it is not difficult to see that when each of these large classes comes to be distinguishable into sub-classes—say by means of differences of colour—the experiences of the two groups A B C D L S, and A B C D L T, and of the two groups A B C D M P, and A B C D M Q, may still be severally numerous enough to make the answering psychical actions automatic. But, clearly, along with more involved and more varied groups there must eventually come imperfect psychical cohesions. As, by successive additions of perceived attributes and relations, the psychical states become more complex; and as each more complex combination of psychical states corresponding to a more special kind of object is, by consequence, less frequently repeated in experience; it follows from the general law we are tracing out that its components cannot be so completely integrated. Not only must the clustered internal states by which the clustered external properties are symbolized, be less definitely aggregated (or at any rate the more recently added of them); but the composite impression they form must have a smaller power of producing the specially co-ordinated motions by which a fit adjustment is made.

The implication lies on the surface. If, as the instincts rise higher and higher, they come to include psychical changes that are less and less coherent with their fundamental ones; there must arrive a time when the co-ordination is no longer perfectly regular. If these compound reflex actions, as they grow more compound, also become less decided; it follows that they will eventually become comparatively undecided. They will begin to lose their distinctly automatic character. That which we call Instinct will merge into something higher.

The facts are thus rendered comprehensible. We see that, if produced by experience, the evolution of Instinct must proceed from the simple to the complex, and that by a progression thus wrought out, it must insensibly pass into a higher order of psychical action; which is just what we find it to do in the higher animals.

CHAPTER VI.

MEMORY.

§ 199. That growing complication of the correspondence which, as we have just seen, necessitates a transition from automatic actions to non-automatic actions, brings with it a separation of the process of correspondence into parts. In its simple form, the adjustment of certain inner relations to certain outer relations is one indivisible action; but in its complex form, such adjustment consists of several stages admitting of greater or less dissociation from one another —capable of becoming *fragments of correspondences.* Thus, among others, results the order of psychical actions known as Memory.

While, in any instinctive act, we see an entire process of bringing internal relations into harmony with external relations, Memory, taken alone, exhibits relations in consciousness which do not include any active adjustment of the organism to relations in the environment. Though those successions of ideas which constitute Memory, nearly all represent past experiences of the outer world; yet, as many if not most of them stand for past experiences of the outer world that are fortuitously combined, it is clear that, even considered as fragments of correspondences, they cannot be held to have as marked a harmony with the environment as have the homologous parts of automatic actions. True, each act of recollection is the establishment of an inner relation answering to *some* outer relation; but as that outer relation is often a transitory one, the inner relation established in the act of recollection is often one answering to no relation now existing or ever likely to exist again; and in that sense is not a correspondence. The correspondence here becomes evanescent.

From this it will probably be inferred that a satisfactory account of Memory, as viewed from our present stand-point, is impracticable. The doctrine that all psychical changes are interpretable as incidents of the correspondence between the organism and its environment, seems to be at fault. Besides the fact that part of the psychical changes constituting Memory have reference to no existing outer relations, there is the further fact that many trains of thought have apparently little or nothing to do with adjusting the conduct to the requirements. But though the position of Memory in the psychological system here sketched out, may not be at once understood, we need only pursue the synthesis a step further to see how Memory results from that same process of development by which Instinct, becoming more and more complicated, finally merges into the higher forms of psychical action.

Some clue will be gained on observing that while, on the one hand, Instinct may be regarded as a kind of organized memory; on the other hand, Memory may be regarded as a kind of incipient instinct. The automatic actions of a bee building one of its wax cells, answer to outer relations so constantly experienced that they are, as it were, organically remembered. Conversely, an ordinary recollection implies a cohesion of psychical states which becomes stronger by repetition, and so approximates more and more to the indissoluble, the automatic, or instinctive cohesions. But leaving rough suggestions, let us take up the general argument from the point reached at the close of the last chapter.

§ 200. So long as the psychical changes are completely automatic, Memory, as we understand it, cannot exist—there cannot exist those irregular psychical changes seen in the association of ideas. But when, as a consequence of advancing complexity and decreasing frequency in the groups of external relations responded to, there arise groups of internal relations which are imperfectly organized and fall short of automatic regularity; then, what we call Memory becomes nascent. For the elucidation of this we must again have recourse to symbols.

As before, let A B C D, represent the group of co-existent attributes common to living bodies in general. Let e, f, g, stand for the further attributes distinctive of some class of creatures mostly serving for prey. And let *h*, *k*, be the attributes peculiar to some species of that class, which, when attacked, defends itself in a particular way; while *h*, *m*, are the somewhat similar attributes peculiar to another species whose defence is a retaliation worse than the attack. We have, then, two very similar complex groups of co-existent attributes, A B C D e f g *h* *k*, and A B C D e f g *h* *m*, which, by the hypothesis, are not frequently repeated in experience; but which, when they do occur, are attended by different consequences. The attributes A, B, C, D, being presented in every experience of living creatures, are responded to by automatically-connected internal states. Similarly, e, f, g, the attributes of creatures serving for prey, being extremely general, have also answering internal states that are automatically-connected with the first and with those motor changes which the presentation of prey calls for. But *h*, *k*, and *h*, *m*, not recurring so often, are represented by internal states that are not organically co-ordinated with their respective groups, or with the motor changes which those groups should produce. Such being the conditions of the case, what must happen?

In the first place, the mere complication in the sets of impressions serving as stimuli to special actions, itself implies something like a nascent Memory. For as, on the one hand, the nervous centre by which any impressions A, B, C, D, e, f, g, *h*, *k*, are co-ordinated, cannot receive all these impressions at absolutely the same instant; and as, on the other hand, the special actions to be produced can be produced only by co-operation of all these impressions; it follows that they must severally have some slight persistence, so that the last may arise before the first fades away.

Not to dwell on this, however, let us now observe that since the states answering to *h*, *k*, and those answering to *h*, *m*, have been unfrequently connected with their respective groups of states and the sequent actions, the nervous changes by which they are themselves produced and by which they produce subsequent changes, must be slow. Psychical states that often recur in a given order, not only become increasingly coherent but the transitions from each to the next become more and more rapid; and, conversely, the cohesion of psychical states that have been rarely connected, is not only feeble but the transitions take appreciable times—a fact well exemplified in learning a language. But the tolerably deliberate succession of psychical states is one of the conditions to Memory. A remembrance implies a consciousness, and a consciousness implies a perceptible duration. The nervous states which are gone through instantaneously —as those by which we infer the distances of the objects we look at—do not enter into what we term Memory at all: we are unconscious of them because they have no appreciable persistence. Hence, the occurrence of these comparatively-slow psychical changes is a step towards the evolution of Memory.

A further consequence is now to be noted. When either of the groups of attributes A B C D e f g *h* *k*, or A B C D e f g *h* *m*, is presented, the set of impressions A B C D e f g, produced in common by both of them, and by all creatures serving for prey, tends to excite the actions by which prey is ordinarily caught. At the same time the impression produced by *h k*, or *h m*, as the case may be, tends to excite those modified actions which occurred in experience after it. Not only, however, is the actual production of these modified actions uncertain, from the experience having been insufficiently repeated, but either of the two tendencies must be partially opposed by the other. The impression resulting from the attribute *h*, being common to both groups, tends equally to excite either of the modified sets of actions; while from *k* the incipient effect is a particular mode of attack, and from *m* the incipient effect is running away. Hence, one general and two special sets of actions are instigated; and from the balance of the instigations, it will often happen that no immediate action at all ensues. The various psychical states involved in each set of motions, severally become nascent; but none of them reach that intensity which they would have were the motions performed. In the chief nervous centre the different impressions serve as different motor impulses; and these, being severally supplanted by one another before they pass into actual motor changes, will each of them consist of an incipient or faint form of that nervous state which would have accompanied the actual motor change had it occurred. But such a succession of states constitutes *remembrance* of the motor changes which thus become incipient—constitutes a *memory*. To remember a motion just made with the arm, is to have a feeble repetition of those internal states which accompanied the motion—is to have an incipient excitement of those nerves which were strongly excited during the motion. Thus, then, these nascent nervous excitements that conflict with one another, are really so many *ideas* of the motor changes which, if stronger, they would cause; or rather, they are the objective sides of those changes which are ideas on their subjective sides. Consequently, Memory necessarily comes into existence whenever automatic action is imperfect.

This, however, is not all. Besides a memory of its own movements and modes of action, there results in the organism a memory of those combinations of impressions it receives through the senses. Under its primary form this advance is a concomitant of the advance just described. As the external groups of attributes and relations responded to become more complex, and by implication more infrequent, the answering psychical changes become more loosely connected with one another and with the motor changes appropriate to them; and the groups of impressions being less coherent, a nascent memory of the component impressions becomes possible. But under its secondary or derivative form this advance is a far larger one, as we shall now see. For the same progress which gives the ability to receive the complex impressions required to determine complex actions, gives the ability to receive complex impressions which do not tend to determine any actions at all. Evolution of the senses and the nervous system, while it makes possible the discrimination of various kinds of enemies and prey, by the special combinations of attributes they severally present, also makes possible the discrimination of various other objects. The power of co-ordinating the impressions of size, form, colours, motions, which stand for a particular animal, is likewise a power of co-ordinating the impressions that stand for trees, plants, stones, and surrounding things. Most of these surrounding things, however, have no immediate relations to the needs of the organism—are not habitually followed by special motor changes; and therefore do not tend to excite motor changes. But while the clustered psychical states produced by the clustered properties of inanimate objects have usually no direct connexions with the actions, they have direct connexions with one another of all degrees of constancy; and, by consequence, have all degrees of the tendency to arouse one another. While the absolutely-persistent relations among external attributes, are responded to by inseparable relations of psychical states; the others, in their respective grades of persistence, are responded to by psychical states proportionate in their degrees of cohesion. Hence, of the impressions produced by adjacent objects during the movements of the organism, each is apt to make nascent certain other impressions with which it has been connected in experience—calls up ideas of such other impressions; that is, causes a remembrance of the attributes previously found in connexion with the perceived attributes. As these psychical states have in their turns been connected with others, they tend to arouse such others; and thus there arises that succession of ideas, partly regular, partly irregular, which we call Memory—regular in so far as the connexions of external phenomena are regular, and irregular in so far as the groups of those phenomena occur irregularly in the environment.

§ 201. This truth, that Memory comes into existence when the involved connexions among psychical states render their successions imperfectly automatic, is in harmony with the obverse truth, that as fast as those connexions among psychical states which we form in Memory, grow by constant repetition automatic, they cease to be part of Memory. We do not speak of ourselves as recollecting relations which have become organically registered. We recollect those relations only of which the registration is incomplete. No one remembers that the object at which he looks has an opposite side; or that a certain modification of the visual impression implies a certain distance; or that the thing he sees moving about is a live animal. To ask a man whether he remembers that the sun shines, that fire burns, that iron is hard, would be a misuse of language. Even the almost fortuitous connexions among our experiences, cease to be classed as memories when they have become thoroughly familiar. Though, on hearing the voice of some unseen person slightly known to us, we say we recollect to whom the voice belongs, we do not use the same expression respecting the voices of those with whom we live. The meanings of words which in childhood have to be consciously recalled, seem in adult life to be immediately present. But the clearest instance of the gradual lapse of memory into automatic coherence, is yielded by the musician. Originally, he was taught that each mark on the paper has a certain name, and implies that a particular key on the piano is to be struck; and during his first lessons, each recurrence of this mark was accompanied with a distinct process of recollecting which key on the piano he must strike. By long-continued practice, however, the series of psychical changes that occur between seeing this mark and striking this key, have been reduced into one almost automatic change. The visual perception of the crotchet or quaver; the perception of its position on the lines of the stave, and of its relation to the beginning of the bar; the consciousness of the place on the piano where the answering key lies; the consciousness of the muscular adjustments required to bring the arm, hand, and finger, into the attitudes requisite for touching that key; the consciousness of the muscular impulse which will give a blow of the due strength, and of the time during which the muscles must be kept contracted to produce the right length of note—all these mental states, which were at first so many separate recollections, ultimately constitute a succession so rapid that the whole of them pass in an instant. As fast as they cease to be distinct states of mind—as fast as they cease to fill appreciable places in consciousness, so fast do they become automatic. The two things are two sides of the same thing. And thus it happens that the practised pianist can play while conversing with those around—while his memory is occupied with quite other ideas than the meanings of the signs before him.

Now the fact that in ourselves psychical states which are originally connected by the process we call recollection, become, by perpetual repetition, connected automatically or instinctively, is manifestly the obverse of the fact that as, in the development of the instincts, the psychical states grow into more involved groups that are less frequently repeated, there occur among them connexions that are not automatic, and memory commences. Our inductive knowledge of the one fact confirms our deduction of the other.

§ 202. Memory, then, pertains to that class of psychical states which are in process of being organized. It continues so long as the organizing of them continues, and disappears when the organization of them is complete. In the advance of the correspondence, each more complex cluster of attributes and relations which a creature acquires the power of recognizing, is responded to at first irregularly and uncertainly; and there is then a weak remembrance. By multiplication of experiences this remembrance is made stronger—the internal cohesions are better adjusted to the external persistences; and the response is rendered more appropriate. By further multiplication of experiences, the internal relations are at last structurally registered in harmony with the external ones; and so, conscious memory passes into unconscious or organic memory. At the same time, a new and still more complex order of experiences is rendered appreciable. The relations that occur between these groups of phenomena that have thus been severally integrated in consciousness, occupy Memory in place of the relations between the components of each group. These become gradually organized; and, like the previous ones, are succeeded by others more complex still.

CHAPTER VII.

REASON.

§ 203. That the commonly-assumed *hiatus* between Reason and Instinct has no existence, is implied both in the argument of the last few chapters and in that more general argument elaborated in the preceding part. The General Synthesis, by showing that all intelligent action whatever is the effecting of correspondences between internal changes and external co-existences and sequences, and by showing that this continuous adjustment of inner to outer relations progresses in Space, in Time, in Speciality, in Generality, and in Complexity, through insensible gradations; implied that the highest forms of psychical activity arise little by little out of the lowest, and cannot be definitely separated from them. Not only does the recently-enunciated doctrine, that the growth of intelligence is throughout determined by the repetition of experiences, involve the continuity of Reason with Instinct; but this continuity is involved in the previously-enunciated doctrine.

The impossibility of establishing any line of demarkation between the two may be clearly demonstrated. If every instinctive action is an adjustment of inner relations to outer relations, and if every rational action is also an adjustment of inner relations to outer relations; then, any alleged distinction can have no other basis than some difference in the characters of the relations to which the adjustments are made. It must be that while, in Instinct the correspondence is between inner and outer relations that are very simple or general; in Reason, the correspondence is between inner and outer relations that are complex, or special, or abstract, or infrequent. But the complexity, speciality, abstractness, and infrequency of relations, are entirely matters of degree. From a group of two co-existent attributes, up through groups of three, four, five, six, seven co-existent attributes, we may step by step ascend to such involved groups of co-existent attributes as are exhibited in a living body under a particular state of feeling, or under a particular physical disorder. Between relations experienced every moment and relations experienced but once in a life, there are relations that occur with all degrees of commonness. How then can any particular phase of complexity or infrequency be fixed upon as that at which Instinct ends and Reason begins?

From whatever point of view regarded, the facts imply a gradual transition from the lower forms of psychical action to the higher. That progressive complication of the instincts, which, as we have found, involves a progressive diminution of their purely automatic character, likewise involves a simultaneous commencement of Memory and Reason. But this joint evolution must be specifically described.

§ 204. When the correspondence has advanced to those environing objects and acts which present groups of attributes and relations of considerable complexity, and which occur with comparative rareness—when, consequently, the repetition of experiences has been insufficient to make the sensory changes produced by such groups cohere perfectly with the adapted motor changes—when such motor changes and the impressions that accompany them simply become nascent; then, by implication, there result *ideas* of such motor changes and impressions, or, as already explained, *memories* of the motor changes before performed under like circumstances, and of the concomitant impressions. Did the process end here, there would be no manifestation of rationality. But the process does not end here, as we shall soon see.

For though when the confusion of a complex impression with some allied one causes a confusion among the nascent motor excitations, there is entailed a certain hesitation; and though this hesitation continues as long as these nascent motor excitations, or ideas of the correlative actions, go on superseding one another; yet, ultimately, some one set of motor excitations will prevail over the rest. As the groups of antagonistic tendencies aroused will scarcely ever be exactly balanced, the strongest group will at length pass into action; and as this sequence will usually be the one that has recurred oftenest in experience, the action will, on the average of cases, be the one best adapted to the circumstances. But an action thus produced is nothing else than a rational action. Each of the actions which we call rational, presents three phases answering to those here described:—first, a certain combination of impressions signifying some combination of phenomena to which the organism is to be adjusted; second, an idea of the actions before performed under like conditions, which idea is a nascent excitation of the nervous agents before concerned in such actions, either as producers of them or as affected by the production of them; and, third, the actions themselves, which are simply the results of the nascent excitation rising into an actual excitation. An illustration will make this clear. A snarling dog commonly turns tail when a stone is thrown at him; or even when he sees the stooping motion required for picking up a stone. Suppose that, having often experienced this sequence, I am again attacked by such a dog; what are the resulting psychical processes? The combined impressions produced on my senses, and the state of consciousness which they arouse, have before been followed by those motor changes required for picking up and throwing a stone, and by those visual changes resulting from the dog's retreat. As these psychical states have repeatedly succeeded one another in experience, they have acquired some cohesion—there is a tendency for the psychical states excited in me by the snarling dog, to be followed by those other psychical states that have before followed them. In other words, there is a nascent excitation of the motor apparatus concerned in picking up and throwing; there is a nascent excitation of all the sensory nerves affected during such acts; and, through these, there is a nascent excitation of the visual nerves, which on previous occasions received impressions of a flying dog. That is, I have the *ideas* of picking up and throwing a stone, and of seeing a dog run away; for these that we call ideas, are nothing else than weak repetitions of the psychical states caused by actual impressions and motions. But what happens further? If there is no antagonist impulse—if no other ideas or partial excitations arise, and if the dog's aggressive demonstrations produce in me feelings of adequate vividness, these partial excitations pass into complete excitations. I go through the previously-imagined actions. The nascent motor changes become real motor changes; and the adjustment of inner relations to outer relations is completed. This, however, is just the process which we saw must arise whenever, from increasing complexity and decreasing frequency, the automatic adjustment of inner to outer relations becomes uncertain or hesitating. Hence it is clear that the actions we call instinctive pass gradually into the actions we call rational.

Further proof is furnished by the converse fact, that the actions we call rational are, by long-continued repetition, rendered automatic or instinctive. By implication, this lapsing of reason into instinct was shown in the last chapter, when exemplifying the lapsing of memory into instinct: the two facts are different aspects of the same fact. But some instances specially exhibiting this second aspect may here be fitly given. Take, as one, the actions gone through in shaving, or in tying a neckerchief. Every man will remember that when, as a youth, he first attempted to guide his hands by watching the reflections of them in the looking-glass, he was unable to move them rightly. The ordinary connexions between the visual impressions received from his moving fingers, and the muscular feelings accompanying their motions, no longer holding good when he had to deal with the images of his fingers, he was led to make movements contrary to those he intended. Only after setting himself to watch how the muscular feelings and the reflected appearances are related, and then consciously making a certain motion in expectation of a certain appearance, did he slowly master the difficulty. By daily practice, however, these psychical changes have become so well co-ordinated, that he now shaves while thinking of something else. Still more marked is the analogous process that occurs in the microscopist. Whatever he places under the object glass is seen inverted, and with its right and left sides interchanged. All adjustments of the stage and all motions of his dissecting instruments, have to be made in directions opposite to those which the uninitiated eye would dictate. Yet habit renders this reversed manipulation as easy as ordinary manipulation—it becomes as unnecessary for the microscopist to take thought how he shall move his hands in the one case as in the other. The approximately-automatic character of habitual actions is clearly proved when they are performed, as they often are, inappropriately. Any one accustomed to traverse particular streets on his way to some place of business, finds that, when intending to branch-off elsewhere, he is apt, if engaged in thought, to follow the usual route—often for a long way beyond the point at which he should have diverged: the impressions received from the familiar objects he passes, cause him to make the ordinary crossings and turnings. In reading aloud, again, the law is well displayed. Originally, sight of the letters was followed by thought of the sounds; and thought of the sounds, by such vocal actions as made the sounds. But eventually, the connexions between visual impressions and vocal actions grow so far automatic, that it becomes possible to read aloud sentence after sentence while occupied in thinking of something else—while unconscious of the words uttered and the ideas conveyed by them. In short, many if not most of our common daily actions (actions every step of which was originally preceded by a consciousness of consequences and was therefore rational) have, by perpetual repetition, been rendered more or less automatic. The requisite impressions being made on us, the appropriate movements follow; without memory, reason, or volition, coming into play.

§ 205. A further interpretation here becomes possible. We have seen that rational action arises out of instinctive action when this grows too complex to be perfectly automatic. We have now to observe that, at the same time, there arises that kind of reasoning which does not directly lead to action—that reasoning through which the great mass of surrounding co-existences and sequences are known.

As fast as the groups of external attributes and relations recognized, become too complex to be consolidated into single psychical states, there result both the opportunity and the power of inferring such attributes or relations belonging to any group, as are not immediately presented. Pure instinct continues so long as the stimuli responded to are made up of few and constant components. While the combined impressions of colour, position, size, and motion, which together stand for an adjacent object that can be seized for prey, are alone receivable, the actions will be purely automatic. But by the time that the organization of experiences has given a power of appreciating the complicated relations of form, of mixed colouring, of peculiar motions, &c., along with the more general ones of colour, position, size, and motion; the attributes and relations united into a group, have grown not only too numerous to be all *mentally* presented at the same instant, but too numerous to be all *physically* presented at the same instant. For the same experiences which have rendered these complex groups of attributes cognizable, have also brought them before the senses in such various ways, that sometimes one part of a group has been perceptible and sometimes another part of it: now these elements of an animal's form and markings and actions have been visible, and now those. Though on the average each experience of the group has resembled previous ones, yet it has presented some attributes which they did not present, and has not presented others which they did present. Hence, by an accumulation of such experiences, each complex group of external phenomena establishes in the organism an answering complex group of psychical states, which has the peculiarity that it contains more states than were ever produced, or ever can be produced, by any one presentation of the external group. What must happen from this? It must happen that when, on any future presentation of the external group, certain of these aggregated psychical states are directly produced by the impressions made on the senses, various others of the psychical states that have been aggregated with them, or made coherent to them by experience, will become nascent: the ideas of one or more unperceived attributes will be aroused: the unperceived attributes will be *inferred.*

Here, also, the doctrine enunciated is verified by the established truth of its obverse. We lately saw that while, on the one hand, instinctive actions pass into rational actions when from increasing complexity and infrequency they become imperfectly automatic; on the other hand, rational actions pass, by constant repetition, into automatic or instinctive actions. Similarly, we may here see that while, on the one hand, rational inferences arise when the groups of attributes and relations cognized become such that the impressions of them cannot be simultaneously co-ordinated; on the other hand, rational inferences pass, by constant recurrence, into automatic inferences or organic intuitions. All acquired perceptions exemplify this truth. The numberless cases in which we seem directly to know the distances, forms, solidities, textures, &c., of the things around us, are cases in which psychical states originally answering to phenomena separately perceived, and afterwards connected in thought by inference, have, by repetition, become indissolubly united, so as to constitute a rational knowledge that appears intuitive.

Thus, the experience-hypothesis furnishes an adequate solution. The genesis of instinct, the development of memory and reason out of it, and the consolidation of rational actions and inferences into instinctive ones, are alike explicable on the single principle, that the cohesion between psychical states is proportionate to the frequency with which the relation between the answering external phenomena has been repeated in experience.

§ 206. But does the experience-hypothesis also explain the evolution of the higher forms of rationality out of the lower? It does. Beginning with reasoning from particulars to particulars—familiarly exhibited by children and by domestic animals—the progress to inductive and deductive reasoning is similarly unbroken, as well as similarly determined. And by the accumulation of experiences is also determined the advance from narrow generalizations to generalizations successively wider and wider.

Were it not for the prevalent anxiety to establish some absolute distinction between animal intelligence and human intelligence, it would be needless to assign proof of this. Even as it is, the truth is so manifest that under most of its aspects none question it. Every one admits that the infant, while occupied in drawing those simplest inferences which by and by become consolidated into acquired perceptions, is exercising no higher rationality than the dog that recognizes his own name, the different members of the household, and the hours of meals. Every one must also admit that the steps by which these simplest inferences of the infant pass into those inferences of high complexity drawn in adult life, are so gradual that it is impossible to mark the successive steps: no one can name that day in any human life when the alleged division between special and general conclusions was crossed. Hence, every one is bound to admit that as the rationality of an infant is no higher than that of a dog, if so high; and as, from the rationality of the infant to that of the man the progress is through gradations which are infinitesimal; there is also a series of infinitesimal gradations through which brute rationality may pass into human rationality. Further, it must be admitted that as the assimilation of experiences of successively-increasing complexity, suffices for the unfolding of reason in the individual human being; so must it suffice for the evolution of reason in general.

Equally clear is the argument from the history of civilization or from the comparison of existing races of men. That there is an immense difference in abstractness between the reasonings of the aboriginal races who peopled Britain, and the reasonings of the Bacons and Newtons who have descended from them, is a trite remark. That the Papuan cannot draw inferences approaching in complexity to those daily drawn by European *savants*, is no less a platitude. Yet no one alleges an absolute distinction between our faculties and those of our remote ancestors, or between the faculties of civilized men and those of savages. Fortunately, there are records showing that the advance towards conceptions of great complication and high generality, has taken place by slow steps—by natural growth. Let us glance at them. Simple numeration existed before arithmetic; arithmetic before algebra; algebra before the infinitesimal calculus; and the more special forms of the infinitesimal calculus before its more general forms. The law of the scales was known before the general law of the lever was known; the law of the lever was known before the laws of composition and resolution of forces were known; and these were known before the laws of motion under their universal forms were known. From the ancient doctrine that the curve in which the sun, the moon, and each of the planets, moves, is a circle (a perfectly simple and constant figure); to the doctrine taught by Kepler, that each member of the planetary system describes an ellipse (a much less simple and constant figure); and afterwards to the doctrine taught by Newton, that the curve described by every heavenly body is some conic section (a still less simple and constant figure); the advance in generality, in complexity, in abstractness, is manifest. Numerous like illustrations are furnished by Physics, by Chemistry, by Physiology: all of them showing, in common with the foregoing ones, that the advance has been gradual, and that each more general relation has become known through the experience of relations a degree less general. If, then, we have proof that in the course of civilization there has been an advance from rational cognitions of a low order of generality to those of a high order of generality, brought about solely by the accumulation of experiences; if this advance is as great as that from the higher forms of brute rationality to the lower forms of human rationality (which no one who compares the generalizations of a Hottentot with those of La Place can deny); it is a legitimate conclusion that the accumulation of experiences suffices to account for the evolution of all rationality out of its simplest forms. The distinction, contended for by Whately, between special reasoning and general reasoning, is untenable. Generality is entirely a thing of degree; and unless it be asserted that the rational faculty of the cultivated European is essentially different from that of a savage or a child, it cannot consistently be asserted that there is any essential difference between brute reason and human reason.

§ 207. To complete the argument it needs but to show, by a special synthesis, that the establishment of every generalization, simple or complex, concrete or abstract, is definitely explicable in conformity with the principle hitherto traced. The general law that the cohesion of psychical states is determined by the frequency with which they have followed one another in experience, affords a satisfactory solution of the highest as of the lowest psychological phenomena. When treating of the integration of correspondences, something was done towards showing that the formation of the most extended generalizations does not differ in method from the formation of the simplest perceptions; but here, this may be more definitely shown.

As an instance let us take the discovery of the relation between degree of evolution of the nervous system and degree of intelligence. Originally, no such relation was recognized or was suspected. It was known that certain creatures have more sagacity than others. It was known that certain creatures have larger heads than others. To some it was known that the larger heads commonly contain larger masses of soft whitish matter. But the causal connexions among these traits were obscured by other connexions. Intelligent creatures were seen to have various other characteristics besides large brains. Most of them are four-legged; most of them are covered with fur; most of them have teeth. And creatures having large brains were seen to have other characteristics than that of intelligence: as strength, length of life, viviparousness. Hence, there was at first no reason why height of intelligence and extent of nervous development, should be thought of together. What, then, was needed to establish a mental connexion between them? Nothing but an accumulation of experiences; or, as we say—a multiplying of observations. That the rationale of this, and its conformity to the general law, may be understood, let us have recourse to symbols. Let A stand for the known characteristic, intelligence.

And let us put X to represent the unknown characteristic on which it is dependent—a developed nervous system. Now A is found along with many varieties of size, form, colour, structure, habit, &c.; and X co-exists with this, that, and the other peculiarity, besides intelligence. That is to say, there are many different groups of attributes variously associated with A and X, and by which the relation of A to X is disguised; or, to continue the symbols—there are groups, B C D X L F Z A, P L F A Q N X Y, E D Z R X B A O Y, and so on, in countless combinations. But now if, other things being equal, the cohesion of psychical states is proportionate to the number of times they have been connected in experience, what must result in the minds of those who are continually impressed with groups of attributes which, differing as they do in other respects, are alike in presenting the relation A to X? As the relation of A to X is constant; as the relations of A to any other attribute, and of X to any other attribute, are not constant; as, consequently, the relation of A to X occurs with greater frequency than the relation of A to anything else, or of X to anything else; it follows from the general law that the psychical states answering to A and X, will become more coherent to each other than either is to the rest of the states with which they occur—there will eventually arise a tendency for A to call up X, and for X to call up A. In other words, A and X will be connected in thought as attributes that constantly co-exist; and so will be established the generalization that the degree of intelligence varies as the development of the nervous system.

Manifestly, the same reasoning holds however complicated the relations, and however greatly obscured. Involved and varied as may be the phenomena to be generalized, if there has already been reached that grade of intelligence required for cognition of the complex terms of the relation common to them; then, repeated experiences will eventually generalize the relation, in virtue of that same simple law of psychical changes which we have found sufficient to explain the lower phenomena of intelligence.

§ 208. Here seems to be the fittest place for pointing out how the general doctrine that has been developed, supplies a reconciliation between the experience-hypothesis as commonly interpreted, and the hypothesis which the transcendentalists oppose to it.*

* In the first edition of this work there here followed a paragraph which is no longer required, nor can indeed be properly embodied in the text—a paragraph expressing a belief in the natural genesis of organic forms, in contrast with the current belief in their supernatural genesis. But while this paragraph is now needless, it formed a needful part of the argument as originally worked out; and I here append it for this reason, as well as for the purpose of indicating the view I held on the question of the origin of species at the time when the first edition of this work was published in 1855. The paragraph is intentionally reproduced without verbal amendments or changes of any kind.

"As most who have read thus far will have perceived, both the general argument unfolded in the synthetical divisions of this work, and many of the special arguments by which it has been supported, imply a tacit adhesion to the development hypothesis—the hypothesis that Life in its multitudinous and infinitely-varied embodiments, has arisen out of the lowest and simplest beginnings, by steps as gradual as those which evolve a homogeneous microscopic germ into a complex organism. This tacit adhesion, which the progress of the argument has rendered much more obvious than I anticipated it would become, I do not hesitate to acknowledge. Not, indeed, that I adopt the current edition of the hypothesis. Ever since the recent revival of the controversy of 'law *versus* miracle,' I have not ceased to regret that so unfortunate a statement of the law should have been given—a statement quite irreconcilable with very obvious truths, and one that not only suggests insurmountable objections, but makes over to opponents a vast series of facts which, rightly interpreted, would tell with great force against them. [This referred to the *Vestiges of the Natural History of Creation.*] What may be a better statement of the law, this is not the place to inquire. It must suffice to enunciate the belief that Life under all its forms has arisen by a progressive, unbroken evolution; and through the immediate instrumentality of what we call natural causes. That this is an hypothesis, I readily admit. That it may never be anything more, seems probable. That even in its most defensible shape there are serious difficulties in its way, I cheerfully acknowledge: though, considering the extreme complexity of the phenomena; the entire destruction of

The universal law that, other things equal, the cohesion of psychical states is proportionate to the frequency with which they have followed one another in experience, supplies an explanation of the so-called "forms of thought," as soon as it is supplemented by the law that habitual psychical successions entail some hereditary tendency to such successions, which, under persistent conditions, will become cumulative in generation after generation. We saw that the establishment of those compound reflex actions called instincts, is comprehensible on the principle that inner relations are, by perpetual repetition, organized into correspondence with outer relations. We have now to observe that the establishment of those consolidated, those indissoluble, those instinctive mental relations constituting our ideas of Space and Time, is comprehensible on the same principle. For if even to external relations that are often experienced during the life of a single organism, answering internal relations are established that become next to automatic—if such a combination of psychical changes as that which guides a savage in hitting a bird

the earlier part of the evidence; the fragmentary and obscure character of that which remains; and the total lack of information respecting the infinitely-varied and involved causes that have been at work; it would be strange were there not such difficulties. Imperfect as it is, however, the evidence in favour appears to me greatly to preponderate over the evidence against. Save for those who still adhere to the Hebrew myth, or to the doctrine of special creations derived from it, there is no alternative but this hypothesis or no hypothesis. The neutral state of having no hypothesis, can be completely preserved only so long as the conflicting evidences appear exactly balanced: such a state is one of unstable equilibrium, which can hardly be permanent. For myself, finding that there is *no* positive evidence of special creations, and that there is *some* positive evidence of evolution—alike in the history of the human race, in the modifications undergone by all organisms under changed conditions, in the development of every living creature—I adopt the hypothesis until better instructed: and I see the more reason for doing this, in the facts, that it appears to be the unavoidable conclusion pointed to by the foregoing investigations, and that it furnishes a solution of the controversy between the disciples of Locke and those of Kant."

with an arrow, becomes, by constant repetition, so organized as to be performed almost without thought of the processes of adjustment gone through—and if skill of this kind is so far transmissible that particular races of men become characterized by particular aptitudes, which are nothing else than partially-organized psychical connexions; then, if there exist certain external relations which are experienced by all organisms at all instants of their waking lives—relations which are absolutely constant, absolutely universal—there will be established answering internal relations that are absolutely constant, absolutely universal. Such relations we have in those of Space and Time. The organization of subjective relations adjusted to these objective relations has been cumulative, not in each race of creatures only, but throughout successive races of creatures; and such subjective relations have, therefore, become more consolidated than all others. Being experienced in every perception and every action of each creature, these connexions among outer existences must, for this reason too, be responded to by connexions among inner feelings, that are, above all others, indissoluble. As the substrata of all other relations in the *non-ego*, they must be responded to by conceptions that are the substrata of all other relations in the *ego*. Being the constant and infinitely-repeated elements of thought, they must become the automatic elements of thought—the elements of thought which it is impossible to get rid of—the "forms of intuition."

Such, it seems to me, is the only possible reconciliation between the experience-hypothesis and the hypothesis of the transcendentalists; neither of which is tenable by itself. Insurmountable difficulties are presented by the Kantian doctrine (as we shall hereafter see); and the antagonist doctrine, taken alone, presents difficulties that are equally insurmountable. To rest with the unqualified assertion that, antecedent to experience, the mind is a blank, is to ignore the questions—whence comes the power of organizing experiences? whence arise the different degrees of that power possessed by different races of organisms, and different individuals of the same race? If, at birth, there exists nothing but a passsive receptivity of impressions, why is not a horse as educable as a man? Should it be said that language makes the difference, then why do not the cat and the dog, reared in the same household, arrive at equal degrees and kinds of intelligence? Understood in its current form, the experience-hypothesis implies that the presence of a definitely-organized nervous system is a circumstance of no moment—a fact not needing to be taken into account! Yet it is the all-important fact—the fact to which, in one sense, the criticisms of Liebnitz and others pointed—the fact without which an assimilation of experiences is inexplicable. Throughout the animal kingdom in general, the actions are dependent on the nervous structure. The physiologist shows us that each reflex movement implies the agency of certain nerves and ganglia; that a development of complicated instincts is accompanied by complication of the nervous centres and their commissural connexions; that the same creature in different stages, as larva and imago for example, changes its instincts as its nervous structure changes; and that as we advance to creatures of high intelligence, a vast increase in the size and in the complexity of the nervous system takes place. What is the obvious inference? It is that the ability to co-ordinate impressions and to perform the appropriate actions, always implies the pre-existence of certain nerves arranged in a certain way. What is the meaning of the human brain? It is that the many *established* relations among its parts, stand for so many *established* relations among the psychical changes. Each of the constant connexions among the fibres of the cerebral masses, answers to some constant connexion of phenomena in the experiences of the race. Just as the organized arrangement subsisting between the sensory nerves of the nostrils and the motor nerves of the respiratory muscles, not only makes possible a sneeze, but also, in the newly-born infant, implies sneezings to be hereafter performed; so, all the organized arrangements subsisting among the nerves of the infant's brain, not only make possible certain combinations of impressions, but also imply that such combinations will hereafter be made—imply that there are answering combinations in the outer world—imply a preparedness to cognize these combinations—imply faculties of comprehending them. It is true that the resulting compound psychical changes, do not take place with the same readiness and automatic precision as the simple reflex action instanced—it is true that some individual experiences seem required to establish them. But while this is partly due to the fact that these combinations are highly involved, extremely varied in their modes of occurrence, made up therefore of psychical relations less completely coherent, and hence need further repetitions to perfect them; it is in a much greater degree due to the fact that at birth the organization of the brain is incomplete, and does not cease its spontaneous progress for twenty or thirty years afterwards. Those who contend that knowledge results wholly from the experiences of the individual, ignoring as they do the mental evolution which accompanies the autogenous development of the nervous system, fall into an error as great as if they were to ascribe all bodily growth and structure to exercise, forgetting the innate tendency to assume the adult form. Were the infant born with a full-sized and completely-constructed brain, their position would be less untenable. But, as the case stands, the gradually-increasing intelligence displayed throughout childhood and youth, is more attributable to the completion of the cerebral organization, than to the individual experiences—a truth proved by the fact that in adult life there is sometimes displayed a high endowment of some faculty which, during education, was never brought into play. Doubtless, experiences received by the individual furnish the concrete materials for all thought. Doubtless, the organized and semi-organized arrangements existing among the cerebral nerves, can give no knowledge until there has been a presentation of the external relations to which they correspond. And doubtless, the child's daily observations and reasonings aid the formation of those involved nervous connexions that are in process of spontaneous evolution; just as its daily gambols aid the development of its limbs. But saying this is quite a different thing from saying that its intelligence is wholly *produced* by its experiences. That is an utterly inadmissible doctrine—a doctrine which makes the presence of a brain meaningless—a doctrine which makes idiotcy unaccountable.

In the sense, then, that there exist in the nervous system certain pre-established relations answering to relations in the environment, there is truth in the doctrine of "forms of intuition"—not the truth which its defenders suppose, but a parallel truth. Corresponding to absolute external relations, there are established in the structure of the nervous system absolute internal relations—relations that are potentially present before birth in the shape of definite nervous connexions; that are antecedent to, and independent of, individual experiences; and that are automatically disclosed along with the first cognitions. And, as here understood, it is not only these fundamental relations which are thus pre-determined; but also hosts of other relations of a more or less constant kind, which are congenitally represented by more or less complete nervous connexions. But these pre-determined internal relations, though independent of the experiences of the individual, are not independent of experiences in general: they have been determined by the experiences of preceding organisms. The corollary here drawn from the general argument is, that the human brain is an organized register of infinitely-numerous experiences received during the evolution of life, or rather, during the evolution of that series of organisms through which the human organism has been reached. The effects of the most uniform and frequent of these experiences have been successively bequeathed, principal and interest; and have slowly amounted to that high intelligence which lies latent in the brain of the infant—which the infant in after life exercises and perhaps strengthens or further complicates—and which, with minute additions, it bequeaths to future generations. And thus it happens that the European inherits from twenty to thirty cubic inches more brain than the Papuan. Thus it happens that faculties, as of music, which scarcely exist in some inferior human races, become congenital in superior ones. Thus it happens that out of savages unable to count up to the number of their fingers, and speaking a language containing only nouns and verbs, arise at length our Newtons and Shakspeares.

CHAPTER VIII.

THE FEELINGS.

§ 209. The assertion that those psychical states which we class as Feelings, are involved with, and inseparable from, those which we class as intellectual processes, seems a contradiction to direct internal perceptions. It will, indeed, be at once admitted that intellectual processes cannot be separated from epi-peripheral feelings, real or ideal; since, invariably, these are either the immediate terms, or the ultimate components of the terms, between which relations are established in every cognition. But while all will grant that the feelings initiated in us by the forces of the external world, are, in their presentative or representative forms, the indispensable materials of thought, and that therefore to this extent intellect and feeling cannot be parted; many will demur to the proposition that feelings of the ento-peripheral and central classes are not separable from intellectual processes.

Some approach towards a right comprehension of the matter, will be gained by recalling certain leading conclusions set down among the Inductions of Psychology. We saw that Mind is composed of feelings and the relations between feelings. We saw that the feelings are primarily divisible into the centrally-initiated and the peripherally-initiated; which last are re-divisible into those which are initiated at the outer surface of the body and those which are initiated within the body. On comparing these three great orders of feelings, we found that whereas the epipheripheral are rational to a very great extent, the entoperipheral, and still more the central, have but small aptitudes for entering into relations. Hence, by implication, it was shown that the relational element of Mind is in no case absent. But the relational element of Mind is the intellectual element. Obviously, then, no kind of feeling, sensational or emotional, can be wholly freed from the intellectual element.

Further, this conclusion is implied by the argument elaborated in the foregoing chapters. If all mental phenomena are incidents of the correspondence between the organism and its environment; and if this correspondence passes insensibly from its lowest to its highest forms; then, we may be certain, *à priori*, that no orders of Feelings can be completely disentangled from other phenomena of consciousness. We may infer that they must arise gradually out of the lower forms of psychical action, by steps such as lead to the higher forms of psychical action already traced out; and that they must constitute another aspect of these. This is just what we shall find.

§ 210. Before proceeding to the synthetic interpretation, it may be well to remark that even in our ordinary experiences, the impossibility of dissociating the psychical states classed as intellectual from those seemingly most unlike psychical states classed as emotional, may be discerned. While we continue to compare such extreme forms of the two as an inference and a fit of anger, we may fancy that they are entirely distinct. But if we examine intermediate modes of consciousness, we shall quickly find some which are both cognitive and emotive. Take the state of mind produced by seeing a beautiful statue. Primarily, this is a co-ordination of the visual impressions which the statue gives, resulting in a consciousness of what they mean; and this we call a purely intellectual act. But usually this act cannot be performed without some pleasurable feeling of the emotional order. Should it be said that this emotion arises from the many ideas associated with the human form, the rejoinder is, that though these aid in its production, it cannot be altogether so accounted for; seeing that we feel a kindred pleasure on contemplating a fine building. If it be urged that, even in this case, collateral states of consciousness are induced which suffice to explain the emotion, then, whence results the gratification given on looking at a simple curve—an ellipse or parabola? The manifest difficulty in disentangling the cognitive from the emotive in these cases, becomes, in other cases, an impossibility. Not only does the state of consciousness produced by a melody show us cognition and emotion inextricably entangled, but the state of consciousness produced by a single beautiful tone does so. Not only is a combination of colours, as in a landscape, productive of a pleasurable feeling beyond that due to mere sensations; but there is pleasure accompanying the perception of even one colour, when of great purity or brilliance. Nay, the touch of a perfectly smooth or soft surface causes an agreeable consciousness. In all these cases the simple distinct feeling directly aroused by the outer agent, is joined with some compound vague feeling indirectly aroused. (See § 128.)

Otherwise put, the matter stands thus. The materials dealt with in every cognitive process are either sensations or the representations of them. These sensations, and by implication the representations of them, are habitually in some degree agreeable or disagreeable. Hence, only in those rare cases in which both its terms and its remote associations are absolutely indifferent, can an act of cognition be *absolutely* free from emotion. Conversely, as every emotion involves the presentation or representation of objects and actions; and as the perceptions, and by implication the recollections, of objects and actions, all imply cognitions;

it follows that no emotion can be *absolutely* free from cognition.

§ 211. The relation between intelligence and feeling will be most clearly understood on studying the relation between perception and sensation, which are the simplest forms of the two.

Every sensation, to be known as one, must be perceived; and must so be in one respect a perception. Every perception must be made up of combined sensations; and must so be in one respect sensational. But though they have the same essential elements, these elements are not similarly dominant in the two. In sensation, consciousness is occupied with certain affections of the organism. In perception, consciousness is occupied with the relations among those affections. Sensations are primary undecomposable states of consciousness; while perceptions are secondary decomposable states, consisting of changes from one primary state to another. Hence, as continuance of the primary states is inconsistent with the occurrence of changes, it follows that consciousness of the changes is in antagonism with consciousness of the states between which they occur. So that perception and sensation are, as it were, ever tending to exclude each other, but never succeeding. Indeed, consciousness continues only in virtue of this conflict. Without the primary affections of consciousness, there can be no changes from one primary affection to another; and without changes from one to another, there can be no primary affections, since in the absence of changes consciousness ceases. Neither consciousness of the changes, nor of the affections between which they occur, can exist by itself. Nevertheless, either may so predominate as greatly to subordinate the other. When the changes are so rapid that the states forming their antecedents and consequents do not last for appreciable times, consciousness is almost wholly occupied with changes—with the relations among sensations: sensations are present so far only as is needful for the establishment of relations among them; and we have that condition of consciousness called perception. On the other hand, when the states forming the antecedents and consequents of the changes have considerable persistence, or rather when they are not permanently destroyed by the changes but continually return, and are thus broken by the changes only so far as is needful to maintain consciousness —when, therefore, some one of them by its continuous recurrence, greatly predominates over others; then there results the condition of consciousness called sensation.

Now this is just the relationship which exists throughout between knowing in general and feeling in general. Though differing from Sir William Hamilton respecting the interpretation of the antagonism between perception and sensation, I agree with him in holding that the same antagonism holds between cognition and emotion. The differences are simply differences that arise from successive complications. As, out of those simple perceptions forming the lowest class of cognitions, the higher cognitions result by the compounding of perceptions; so, out of those simple sensations forming the lowest class of feelings, the higher feelings arise by the compounding of sensations. And as, when cognitions grow highly compound their elements become too numerous to be all present together, and so become partly representative, and afterwards sometimes wholly representative; so, when the feelings grow highly compound their elements become too numerous to be all present together, and so become partly representative, and afterwards sometimes wholly representative. These positions require elucidation.

It has been from time to time pointed out that, in the development of Mind, there is a progressive consolidation of states of consciousness. States of consciousness once separate become indissociable. Other states that were originally united with difficulty, grow so coherent as to follow one another without effort. And thus there arise large aggregations of states, answering to complex external things—animals, men, buildings—which are so welded together as to be practically single states. But this integration, by uniting a large number of related sensations into one state, does not destroy them. Though subordinated as parts of a whole, they still exist. And being severally in their original forms, *feelings*, this state which is composed of them is a *feeling*—a feeling produced by the fusing of a number of minor feelings. Hence a certain pleasure accompanying all kinds of perceptions; as every child shows us. Not only, however, does this hold with the groups of simple sensations that are united to form perceptions; but it holds with groups of these groups. When the composite states of consciousness answering to single complex objects, become sufficiently consolidated; then, if the daily experiences present some constant assemblage of complex objects, such as those distinguishing a particular locality, there results a consolidation of these into a still larger aggregate of states: the feelings severally constituted by these composite states, are, in their turn, merged into a more composite feeling, which in its mixed and comparatively massive character verges on the emotional. And then from the union of this composite feeling with other composite feelings, the elements of which are mainly representative, such as those implied in the domestic relations, there is produced an extremely involved and massive feeling of the emotional order, answering to the idea, home. But now let it be remarked that as fast as these compound states of consciousness in their ascending grades, severally become, by integration of their elements, practically single; so fast do they begin to play the same parts in the mental processes that single states do. The continuance of a sensation being inconsistent with the occurrence of a change, we saw that consciousness of changes, or relations among sensations, is ever at variance with consciousness of the sensations. Here we may similarly see that in proportion as a composite feeling including many sensations and their relations, becomes consolidated, its continuance must be at variance with the occurrence of a change to some other composite feeling; that is—must be at variance with the establishment of a relation between the thing causing such composite feeling, and anything else; that is—must be at variance with cognition. And hence arises the fact known to persons analytically inclined, that when they think about any gratification they are receiving—speculate upon the cause of it, or criticise the object of it—the gratification is suspended.

These several expositions have, I think, made it clear that cognition and feeling, throughout all phases of their evolution, are at once antithetical and inseparable. The implication is that they are but different aspects of the same development, and may so be expected to arise from the same root by the same process. This being understood we may now go on to consider the feelings synthetically.

§ 212. Where action is perfectly automatic, feeling does not exist. Of this we have several proofs. We have the proof that in creatures most markedly exhibiting them, automatic actions go on equally well when the chief nervous centre has been removed. We have the proof that our own automatic actions are unaccompanied by feelings: as witness those of the viscera in their normal states. And we have the further proof that actions which in ourselves are partly voluntary, partly reflex (as that by which the foot is withdrawn from the scalding water), and which, so long as they are accompanied by feeling, are accompanied by will, become more energetically automatic if feeling is lost. When injury of the afferent nerves has destroyed sensibility in a limb, the slightest stimulus, as the touch of a feather, produces reflex movements that are stronger than those produced in a limb retaining its sensibility.

This antagonism of automatic action and feeling will be better understood on observing that feeling involves a persistence which automatic action negatives. To have the state of consciousness recognizable as a particular feeling, implies some duration of that state; and in proportion as it fills a smaller interval in the chain of states, in the same proportion does it lapse out of consciousness—in the same proportion does it cease to be felt. The proposition is a truism. To say that a state of consciousness has considerable continuity, is to say that it is a distinct element of consciousness; which is the same thing as being known or felt. To say that it has scarcely any continuity, is to say that it forms a scarcely perceivable element in consciousness; which is the same thing as being scarcely at all known or felt. And to say that it is a state of consciousness having no appreciable length, is to say that it forms no element in consciousness; which is the same thing as being not known or felt. It follows, therefore, that when a set of psychical changes occurs instantaneously, the psychical states forming the antecedents and consequents of the changes are not felt; and the further the consolidation of any set of psychical changes is carried, the more complete must be the absence of feeling. Now the completely-consolidated sets of changes are the automatic changes. The automatic changes are those of which the elements are practically fused into one change. Consequently, where all the psychical actions are perfectly automatic, there is no feeling.

While an entire absence of Memory and Reason is accompanied by an entire absence of Feeling, the same progress which gives origin to Memory and Reason simultaneously gives origin to Feeling. For what did we find to be the circumstances under which Memory and Reason become nascent? We found that when the adjustments of the organism to its environment begin to take in involved and infrequent groups of outer relations—when, consequently, the answering groups of inner relations include many elements, of which some are not often repeated in experience —when, that is, there are formed groups of inner relations whose components are imperfectly coherent—when, as a necessary result, there come to be hesitating automatic actions; then, Memory and Reason simultaneously become nascent. The ceasing to be automatic and the becoming rational, are, as we saw, the same thing. We have just seen, however, that when psychical changes are perfectly automatic, they are without feeling. The existence of feeling we have seen to imply psychical states having some persistence. But psychical states having some persistence are the states which result when automatic action fails. Thus then, as the psychical changes become too complicated to be perfectly automatic, they become incipiently sensational. Memory, Reason, and Feeling take their rise at the same time.

A confirmation of this view, parallel to confirmations given in the two preceding chapters, may be set down. Among our own mental processes, many of which were once slow, and were then accompanied by feeling, are by the same repetition which renders them automatic, also rendered indifferent or feelingless. This is equally the case whether the accompanying feelings are painful or pleasurable. In spelling out its reading-lessons, the child experiences a disagreeable sense of effort; but in the adult, the identification of words is a totally unemotional process. The learning of a new language requires labour that is more or less unpleasant, and the first attempts to speak it soon produce weariness; but after due practice it is spoken with entire indifference. And not to multiply illustrations, I may quote the general remark that habit renders easy the actions that once were hard, as showing that this law holds throughout; since by calling actions *hard* we mean to some extent painful, and becoming *easy* is ceasing to be painful. Equally general is the kindred truth. So long as the combinations of properties they present are new to it, the commonest objects give pleasure to the infant; but as fast as, by constant repetition, the compound impressions produced become consolidated into perfect cognitions of the objects, so fast do the objects become indifferent. Throughout childhood, youth, and manhood, the same fact is daily manifested. The often-repeated groups of psychical changes cease to be interesting; and there arises a demand for those that have not been experienced, or have been little experienced.

The parallel is complete. We found that not only do Memory and Reason begin where the psychical changes cease to be automatic; but that where they have existed they disappear when, by perpetual repetition, the psychical changes become automatic. And here we find both that Feeling arises under the same conditions, and that it ceases under the same conditions.

Let us now devote our attention to the genesis of Feelings of more complex kinds.

§ 213. When there come to be cases in which two very similar groups of external attributes and relations have been followed in experience by different motor changes; and when, consequently, the presentation of one of these groups partially excites two sets of motor changes, each of which is prevented by their mutual antagonism from at once taking place; then, while one of these sets of nascent motor changes and nascent impressions habitually accompanying it, constitutes a *memory* of such motor changes as before performed and impressions as before received, and while it also constitutes a *prevision* of the action appropriate to the new occasion, it further constitutes the *desire* to perform the action. For different as these three things eventually become, they are originally one. A further development of an illustration already used will make this manifest. Suppose the subject of the psychical phenomena we are considering, to have occasional experiences of two animals somewhat similar in colour, size, and general contour, one of which serves for prey and the other of which is a dangerous enemy. The complex impression produced by the enemy, has been followed in experience by injuries, by some defensive actions, by certain cries, and eventually by flight. The complex impression produced by the prey has been followed in experience by motions of pursuit, by successful grappling and biting, by processes of tearing to pieces and swallowing. But as these two complex impressions have many elements in common, each tends in so far as there is a confusion between them, to arouse either of these two sets of psychical changes; and when one of these similar animals is seen, each set becomes nascent according as the impression produced varies. At one moment the defensive actions, the cries, and the movements of escape, which have followed some such impression as that received, tend to arise; and the next moment a change in the position of the perceived animal so alters the impression, as partially to excite the psychical states involved in pursuit, attack, destroying, and devouring. But what is either of these partial excitations? It is nothing else than an emotional impulse—a combination of representative feelings which forms the stimulus to action—a desire To have in a slight degree such psychical states as accompany the reception of wounds, and are experienced during flight, is to be in a state of what we call fear. And to have in a slight degree such psychical states as the processes of catching, killing, and eating imply, is to have the desires to catch, kill, and eat. That the propensities to the acts are nothing else than nascent excitations of the psychical state involved in the acts, is proved by the natural language of the propensities. Fear, when strong, expresses itself in cries, in efforts to escape, in palpitations, in tremblings; and these are just the manifestations that go along with an actual suffering of the evil feared. The destructive passion is shown in a general tension of the muscular system, in gnashing of teeth and protrusion of the claws, in dilated eyes and nostrils, in growls; and these are weaker forms of the actions that accompany the killing of prey. To such objective evidences, every one can add subjective evidences. Every one can testify that the psychical state called fear, consists of mental representations of certain painful results; and that the one called anger, consists of mental representations of the actions and impressions which would occur while inflicting some kind of pain.

Possibly it may be objected, that to describe the group of nascent psychical changes produced by some complex impression, as constituting at once a *memory* of the psychical changes which had before followed this impression and a *desire* again to go through such changes, is absurd; since the subject-matter of memory is retrospective, while that of desire is prospective. The reply is, that though, when a high degree of intelligence has been reached, these nascent changes are joined with a consciousness of time past and time future, and so come to have different aspects; yet, at the stage in which automatic action merges into the higher forms of action, no such abstract conception as that of Time can exist, and no such duality of aspect in these groups of nascent psychical changes can arise. And a further reply is, that even in ourselves, acts and feelings which become nascent in connexion with the idea of something prospective, are at the same time retrospective; since they cannot be represented at all unless they have been previously presented in experience, and the representation of anything previously presented is memory.

§ 214. The progress from these forms of feeling considerably compounded to those highly-compounded forms of feeling seen in human beings, equally harmonizes with the general principles of evolution that have been laid down. We saw that advance from the simplest to the most complex cognitions, is explicable on the principle that the outer relations produce the inner relations. We shall see that this same principle supplies an explanation of the advance from the simplest to the most complex feelings.

For when the development of Life reaches this repeatedly-described stage in which automatic actions merge into actions that are at once conscious, rational, and emotive; what must be the effect of further experiences? The effect must be that if, in connexion with a group of impressions and the nascent motor changes resulting from it, there is habitually experienced some other impression or group of impressions, some other motor change or group of motor changes, this will, in process of time, be rendered so coherent to the original group, that it, too, will become nascent when the original group becomes nascent, and will render the original group nascent if it is itself induced. Let us take a case. If along with the running down of certain prey, a certain scent has been habitually experienced, then, the presentation of that scent will render nascent the motor changes and impressions which accompany the running down of the prey. If the motor changes and impressions that precede and accompany the catching of prey, have been constantly followed by destructive actions, then, when they are rendered nascent, they will in their turn render nascent the psychical states implied by destructive actions. And if these have been followed by those connected with eating, then those connected with eating will also be made nascent. So that the simple olfactory sensation will make nascent those many and varied states of consciousness involved in the running down, catching, killing, and eating of prey: the sensations, visual, auditory, tactual, gustatory, muscular, that are bound up with the successive phases of these actions, will be present to consciousness as what we call ideas—will, in their aggregate, constitute the desires to catch, kill, and devour—and will, in conjunction with that olfactory sensation which aroused them all, form the impulse which sets going the limbs in pursuit. The entire genesis of these emotions thus results from successive complications in the groups of psychical states that are co-ordinated; and is just as much determined by experience as is the union of any two simple sensations that constantly occur together.

A like explanation may be given of emotions which leave the subject of them comparatively passive; as, for instance, that produced by scenery. By compounding groups of sensations and ideas there are at length formed those vast aggregations which a grand landscape excites and suggests. An infant taken into the midst of mountains, is totally unaffected; but is delighted with the small group of attributes and relations presented in a toy. Children can appreciate, and be pleased with, the more complicated relations of household objects and localities—of the garden, the field, and the street. But it is only in youth and mature age, when individual things and small assemblages of them have become familiar and are automatically cognizable, that those immense assemblages which landscapes present can be adequately grasped, and the highly integrated states of consciousness produced by them, experienced. Then, however, the various minor groups of states that have been in earlier days severally produced by trees and flowers, by fields and moors and rocky wastes, by streams, by cascades, by ravines and precipices, by blue skies and clouds and storms, are aroused together. Along with the immediate sensations there are partially excited the myriads of sensations that have been in times past received from objects such as those presented; further, there are partially excited the multitudinous incidental feelings that were experienced on these many past occasions; and there are also excited certain deeper, but now vague, combinations of states which were organized in the race during barbarous times, when its pleasurable activities were chiefly among the woods and waters. And out of all these excitations, some of them actual but most of them nascent, is composed the emotion which a fine landscape produces in us.

§ 215. One of the corollaries from the foregoing doctrines is that, other things equal, feelings are strong in proportion as they include many actual sensations, or nascent sensations, or both. As every one of the elementary states of consciousness aggregated in the way described, is originally a feeling of some kind; and as progressive integration though it abbreviates each, leaves it to the last a feeling, however infinitesimal in amount; it follows that the greater the accumulation of such infinitesimal amounts of feeling, the greater must be the sum total of feeling experienced. Quantity of feeling is of two kinds—that which arises from intense excitation of few nerves, and that which arises from slight excitation of many nerves. Thus, an unbearable sensation results if the tip of a finger be held in boiling water. Conversely, though there is no difficulty in holding the tip of a finger in water above 110° Fahrenheit, an unbearable sensation results if the whole body be plunged into water of that temperature. So that the moderate excitation of all the nerves distributed over the surface of the body, is equivalent, as measured by its motor effects, to the extreme excitation of a few of them. Similarly, though a very faint colour cannot be discerned when it covers only a very minute surface; yet, when it covers a great surface it can be discerned with ease. And that the truth thus holding with actual sensations, holds also with those nascent sensations which, as aggregated into masses of ideas, distinct and indistinct, constitute the emotions, will be manifest on calling to mind how actions are continually determined by the accumulation of motives; that is, by the accumulation of such nascent feelings.

From this corollary there is a second corollary. With a qualification to be hereafter made, the higher the evolution rises the stronger do the emotions become. For as the increasingly-complex emotions successively developed, result from integration of pre-existing groups of actual and nascent sensations, the resulting totals must grow continually larger. A marked illustration of this truth is furnished by the passion which unites the sexes. This is habitually spoken of as though it were a simple feeling; whereas it is the most compound, and therefore the most powerful, of all the feelings. Added to the purely physical elements of it, are first to be noticed those highly complex impressions produced by personal beauty; around which are aggregated a variety of pleasurable ideas, not in themselves amatory, but which have an organized relation to the amatory feeling. With this there is united the complex sentiment which we term affection—a sentiment which, as it can exist between those of the same sex, must be regarded as an independent sentiment, but one which is here greatly exalted. Then there is the sentiment of admiration, respect, or reverence: in itself one of considerable power, and which in this relation becomes in a high degree active. There comes next the feeling called love of approbation. To be preferred above all the world, and that by one admired beyond all others, is to have the love of approbation gratified in a degree passing every previous experience: especially as there is added that indirect gratification of it which results from the preference being witnessed by unconcerned persons. Further, the allied emotion of self-esteem comes into play. To have succeeded in gaining such attachment from, and sway over, another, is a proof of power which cannot fail agreeably to excite the *amour propre.* Yet again, the proprietary feeling has its share in the general activity: there is the pleasure of possession—the two belong to each other. Once more, the relation allows of an extended liberty of action. Towards other persons a restrained behaviour is requisite. Round each there is a subtle boundary that may not be crossed—an individuality on which none may trespass. But in this case the barriers are thrown down; and thus the love of unrestrained activity is gratified. Finally, there is an exaltation of the sympathies. Egoistic pleasures of all kinds are doubled by another's sympathetic participation; and the pleasures of another are added to the egoistic pleasures. Thus, round the physical feeling forming the nucleus of the whole, are gathered the feelings produced by personal beauty, that constituting simple attachment, those of reverence, of love of approbation, of self-esteem, of property, of love of freedom, of sympathy. These, all greatly exalted, and severally tending to reflect their excitements on one another, unite to form the mental state we call love. And as each of them is itself comprehensive of multitudinous states of consciousness, we may say that this passion fuses into one immense aggregate most of the elementary excitations of which we are capable; and that hence results its irresistible power.

Other emotions than those which arise by the simple aggregation of large groups of psychical states into still larger groups, are similarly interpretable. There goes on at the same time, and as a result of the same cause, an evolution of emotions that are not only more complex, but also more abstract. Of this, the love of property supplies an example. When the development of intelligence has rendered time and locality cognizable; and when, by consequence, an uneaten portion of food can, when hunger next makes nascent the psychical states that accompany eating, be remembered as having been left in a particular place; then, repetition of these experiences of a satiated hunger, and a subsequently-recurring hunger that prompts return to the remaining food, will establish an organized connexion between the remembrance of such remaining food and the various states of consciousness produced by a return to it. Thus will be constituted an anticipation of a return to it—a tendency to perform all such actions accompanying a return to it as are not negatived by satiety—a tendency, therefore, to take possession of it. An analogous process will develop a tendency to take possession of some habitual place of shelter; and afterwards to take possession of things serving for artificial shelter and for clothing. Later still, things indirectly connected with personal welfare will come to be included; as, for instance, the club used for a weapon, the impressions produced by which will make nascent the various pleasurable feelings that have accompanied its successful use, and the conception of further use. The same process rising to still higher complications, will generate a propensity to take possession not only of various weapons and appliances of daily life, but also of the tools and materials required to make such weapons and appliances; afterwards of the materials required to make such tools; and so on until the things accumulated for one purpose or other become numerous and varied. But now observe that in proportion as these things become numerous and varied, and in proportion as the acts of acquiring them and preserving them become frequent, a great variety of pleasurable excitements will come to be associated with the act of taking possession or holding possession. Hence this act itself, being continually the initiator of pleasurable excitements, will become a source of pleasurable excitement. And as the excitement thus caused must be more habitual than that caused by any particular order of objects; as, further, the special excitements attaching to special objects possessed, must, in virtue of their variety, prevent the excitement of possession from being connected with any one of them in particular; it results that the excitement of possession will grow into one of a new kind, uniting into a large but vague aggregate the various excitements to which it ministers. And when money comes to be the representative of value in general—value as abstracted from special objects—the miser shows us how the desire of possession in the abstract may become almost independent of those from which it arose; and may exceed in strength any of them individually.

As further illustrating the origin and nature of the more abstract emotions, let me add one still in course of evolution among civilized men; and as yet but imperfectly developed. I refer to the desire for liberty—the sentiment of personal rights. A relation like that which the love of property bears to the gratifications which property brings, this love of unrestricted action bears to the gratifications derivable from property and from all other things. As the satisfaction of the one is in securing the *material objects* directly or indirectly ministering to life; so the satisfaction of the other is in securing those *non-material conditions* without which the material objects can neither be obtained, nor preserved, nor used. While the possession of certain kinds and combinations of *matter* is a very general pre-requisite to the fulfilment of the desires; a still more general, and indeed universal, pre-requisite is that freedom of *motion* without which it is not only impossible to get and utilize such matter, but is impossible to perform any action whatever. This sentiment of personal rights, answering to certain complex relations in which the members of a society stand to one another—being a gratification in the maintenance of such relations with other men as involve the least restraint on individual action—is manifestly far more abstract, and far wider in its co-ordinations, than any other. As uniting in one general sentiment the desire for liberty of person, liberty of acquisition and possession, liberty of movement from place to place, liberty of speech, liberty of trade, and so on, it supposes an extremely extensive aggregation of psychical states. It could not begin to be organized until mankind grew into permanent social relations, and it has manifestly long been in process of development.

It remains to add the qualification which, as above said, must be made to the assertion that these central feelings or emotions grow in power as they grow in complexity and in extent of integration. For though, other things equal, the power of an emotion thus compounded out of clusters of elementary feelings ideally revived, is proportionate to the number of such elementary feelings united in it; yet, very often other things are *not* equal. Along with greatness of number there may be lowness of intensity. Where, as in the above case, the connexions established in experience are extremely intricate, comparatively infrequent, and very varied, the co-ordination of the states of consciousness is so weak that they render one another nascent in but a feeble way; and hence, the total effect is in many cases less than that produced by a smaller aggregate more strongly excited.

§ 216. After what was said at the close of the last chapter, I need hardly say that this evolution of composite feelings through the progressive integration of psychical states that are connected in experience, is effected by the inheritance of continually-accumulating modifications.

The law of development of the mental activities considered under their cognitive aspect, equally applies to them considered under their emotional aspect. That gradual organization of forms of thought which we saw results from the experience of uniform external relations, is accompanied by the organization of forms of feeling similarly resulting. Given a race of organisms habitually placed in contact with any complex set of circumstances, and if its members are already able to co-ordinate the impressions made by each of the various minor groups of phenomena composing this set of circumstances, there will slowly be established in them a co-ordination of these compound impressions corresponding to this set of circumstances. The constant experiences of successive generations will gradually strengthen the tendency of all the component clusters of psychical states to make one another nascent. And when ultimately the union of them, expressed in the inherited organic structure, becomes innate, it will constitute what we call an emotion or sentiment, having this set of circumstances for its object.

In their more involved phases these compound forms of feeling differ from the compound forms of thought partly in this, that the assemblages of external attributes and actions and relations to which they answer, are immensely more extensive, far more concrete, and extremely miscellaneous and variable in their ultimate components. One consequence of this is that they never lose their empirical character. A further difference similarly implied, is that in each form of feeling thus compounded, answering as it does to successive sets of external circumstances which have only a general resemblance, the relational elements are never twice alike, and therefore cannot become distinctly fixed; whence it follows that the cognitive character of the aggregated states remaining feeble, their sentient character remains strong. A third differential trait of these central feelings must be added. As the clusters of elementary feelings out of which they are formed, do not recur in exactly the same combinations—are not, as it were, super-posed so that their components fit with the like previous components; it necessarily happens that the successive clusters blur one another, and the compound feeling produced becomes, though massive, very dim or vague. An illustration will make this effect comprehensible. Imagine that representations of many different sunsets, painted, let us say, on glass, were placed over one another, and looked at by transmitted light—what would be the result? Disagreeing in the outlines of their horizons, their clouds, their special objects, these super-posed representations would make a confused and hazy combination, in which no particular thing and no defined portion of colour would be visible; but in which, nevertheless, there would be these general characters—a glow in the middle region, a duller region above it, and a comparatively dark region below. Similarly, as the successive impressions produced on an individual, and a series of individuals, by manifestations of anger in those they come in contact with, have general but not special resemblances—as the harsh tones, the contorted features, and the pains that are apt to be suffered from the acts which follow, always differ in their details though they have a family likeness; it results that the general impression left unobliterated by the disagreeing details must be very indefinite: the gradually-organized compound feeling which we call fear, will have a character nothing like so specific as that of a simple peripheral feeling.

Such being the differences that naturally arise between the organized forms of feeling and the organized forms or thought in the course of their evolution, let us now observe the likenesses that naturally arise.

As the forms of thought, or the accumulated and transmitted modifications of structure produced by experience, lie latent in each newly-born individual, are vaguely disclosed along with the first individual experiences, and are gradually made definite by multiplication of such individual experiences; so the forms of feeling likewise lying latent, are feebly awakened by the first presentations of the external circumstances to which they refer, and gradually gain that degree of distinctness which they are capable of, through often-repeated presentations of these circumstances. Thus the infant, as soon as its perceptions are developed enough to allow of even an imperfect discrimination of faces and of sounds, is made to smile automatically by the laughing face and tender tones of its mother or its nurse. An organized relation has been established in the race between the perception of this natural language of kind feeling and the subsequent experience of benefits from those who manifest it. This natural language being impressed on the infant's senses, a dim feeling of pleasure is awakened while it is still incapable of knowing what the natural language means. But in course of time personal experiences teach it the connexion that exists between these appearances assumed by other persons and the receipt of gratifications from them; and then the vague body of the emotion which it has inherited assumes a more intelligible form.

That the experience-hypothesis as ordinarily understood, is inadequate to account for emotional phenomena, will be sufficiently manifest. If possible, it is even more at fault in respect to the emotions than in respect to the cognitions. The doctrine that all the desires, all the sentiments, are generated by the experiences of the individual, is so glaringly at variance with facts, that I cannot but wonder how any one should ever have entertained it. Not to dwell on the multiform passions displayed by the infant before there has been such an amount of experience as could possibly suffice for the elaboration of them, I will simply point to the most powerful of passions—the amatory passion—as one which, when it first occurs, is absolutely antecedent to all relative experience whatever.

CHAPTER IX.

THE WILL.

§ 217. All who have followed the argument thus far, will see that the development of what we call Will, is but another aspect of the general process whose other aspects have been delineated in the last three chapters. Memory, Reason, and Feeling, simultaneously arise as the automatic actions become complex, infrequent, and hesitating; and Will, arising at the same time, is necessitated by the same conditions. As the advance from the simple and indissolubly-coherent psychical changes, to the psychical changes that are involved and dissolubly coherent, is in itself the commencement of Memory, Reason, and Feeling; so, too, is it in itself the commencement of Will. On passing from compound reflex actions to those actions so highly compounded as to be imperfectly reflex —on passing from the organically-determined psychical changes which take place with extreme rapidity, to the psychical changes which, not being organically determined, take place with some deliberation, and therefore consciously; we pass to a kind of mental action which is one of Memory, Reason, Feeling, or Will, according to the side of it we look at.

Of this we may be certain, even in anticipation of any special synthesis. For since all modes of consciousness can be nothing else than incidents of the correspondence between the organism and its environment; they must all be different sides of, or different phases of, the co-ordinated groups of changes whereby internal relations are adjusted to external relations. Between the reception of certain impressions and the performance of certain appropriate motions, there is some inner connexion. If the inner connexion is organized, the action is of the reflex order, either simple or compound; and none of the phenomena of consciousness proper, exist. If the inner connexion is not organized, then the psychical changes which come between the impressions and motions are conscious ones: the entire action must have all the essential elements of a conscious action—must simultaneously exhibit Memory, Reason, Feeling, and Will; for there can be no conscious adjustment of an inner to an outer relation without all these being involved. Let us consider the matter more nearly.

§ 218. When the automatic actions become so involved, so varied in kind, and severally so infrequent, as no longer to be performed with unhesitating precision—when, after the reception of one of the more complex impressions, the appropriate motor changes become nascent, but are prevented from passing into immediate action by the antagonism of certain other nascent motor changes appropriate to some nearly allied impression; there is constituted a state of consciousness which, when it finally issues in action, displays what we term volition. Each set of nascent motor changes arising in the course of this conflict, is a weak revival of the state of consciousness which accompanies such motor changes when actually performed—is a representation of such motor changes as were before executed under like circumstances—is an idea of such motor changes. We have, therefore, a conflict between two sets of ideal motor changes which severally tend to become real, and one of which eventually does become real; and this passing of an ideal motor change into a real one, we distinguish as

Will. In a voluntary act of the simplest kind, we can find nothing beyond a mental representation of the act, followed by a performance of it—a rising of that incipient psychical change which constitutes at once the tendency to act and the idea of the act, into the complete psychical change which constitutes the performance of the act, in so far as it is mental. Between an involuntary movement of the leg and a voluntary one, the difference is that whereas the involuntary one occurs without previous consciousness of the movement to be made, the voluntary one occurs only after it has been represented in consciousness; and as the representation of it is nothing else than a weak form of the psychical state accompanying the movement, it is nothing else than a nascent excitation of the nerves concerned, preceding their actual excitation. Involuntary movement implies that the psychical states accompanying the impression and the action, are so coherent that the one follows the other instantly; while voluntary movement implies that they are so imperfectly coherent, that the psychical state accompanying the action does not follow instantly—is partially aroused before it is fully aroused; and so occupies consciousness for an appreciable time. Thus the cessation of automatic action and the dawn of volition are one and the same thing.

It is quite true that as we advance from the earliest and simplest manifestations of Will to its later and more involved manifestations, the composite state of consciousness by which any act is preceded includes much beyond the nascent motor changes, and even much beyond the ideal sensory impressions which the act will immediately render real ones. It further includes an extensive aggregate of ideal sensory impressions such as have before been more or less remotely realized by the act; and which constitute representations of the various consequences of the act. Even when Will is but incipient, there must be some accompaniment of this kind. Along with any two conflicting sets of motor changes produced by an indistinctly cognized impression, there will become nascent the several pleasurable or painful psychical states which have in experience been respectively connected with such motor changes. These are partially integrated with the other psychical states, actual and nascent, which the impression immediately or mediately excites; and by increasing the group of psychical states which cohere with the appropriate motor changes, they add to the tendency which those motor changes have to take place. By that ever-progressing fusion of psychical states described in the last chapter, these ideal sensory impressions representing distant consequences, come to form the greater part of the composite psychical state which precedes the act—constitute the mass of what we call the desire to perform the act; and thus obscure that original relation between sensations and motions which is their nucleus. But the general nature of the process remains the same. Feelings, immediately derived from the senses or mediately suggested by such, make nascent certain appropriate motor changes, and the ideal feelings connected with such changes; these, again, make nascent other changes and other ideal feelings; and so on to many degrees of remoteness: producing a complicated group of imagined actions and consequences. All of these having, directly or indirectly, connexions in experience with the motor changes, or with antagonist motor changes, tend to produce or to prevent the action. An immense number of psychical states are partially aroused, some of which unite with the original impression in exciting the action, while the rest combine as exciters of an opposite action; and when eventually, from their greater number or intensity, the first outbalance the others, the interpretation is that, as an accumulated stimulus, they become sufficiently strong to make the nascent motor changes pass into actual motor changes.

That Will comes into existence through the increasing complexity and imperfect coherence of automatic actions, is clearly implied by the converse fact, that when actions which were once incoherent and voluntary are very frequently repeated, they become coherent and involuntary. Just as any set of psychical changes originally displaying Memory, Reason, and Feeling, cease to be conscious, rational, and emotional, as fast as by repetition they grow closely organized; so do they at the same time pass beyond the sphere of volition. Memory, Reason, Feeling, and Will, simultaneously disappear in proportion as psychical changes become automatic. Thus, the child learning to walk, wills each movement before making it; but the adult, when setting out anywhere, does not think of his legs but of his destination, and his successive steps are made with no more volition than his successive inspirations. Every one of those vocal imitations made by the child in acquiring its mother tongue, or by the man in learning a new language, is voluntarily made; but after years of practice, conversation is carried on without thought of the muscular adjustments required to produce each articulation: the motions of the larynx and mouth respond automatically to the trains of ideas. Similarly with writing, and all other familiar processes. Not only is this so with actions daily occurring in the lives of all, but it is so with special habits. From time to time curious results hence arise; as in the case of the old soldier who let fall the pie he was carrying home for his Sunday's dinner, when the word "attention" was shouted behind him. The same general truth is recognized in the common remark, made of any one who has long persisted in some evil practice, that "he has lost power over himself"—"can no longer control himself:" that is to say, by frequent repetition certain psychical changes have more or less passed from the voluntary into the automatic.*

* Dr. Hughlings Jackson narrates of an animal an action analogous to that of the old soldier. "Some years ago," he says, "I was on an omnibus,

§ 219. Long before reaching this point, most readers must have perceived that the doctrines developed in the last two parts of this work are at variance with the current tenets respecting the freedom of the Will. That every one is at liberty to do what he desires to do (supposing there are no external hindrances), all admit; though people of confused ideas commonly suppose this to be the thing denied. But that every one is at liberty to desire or not to desire, which is the real proposition involved in the dogma of free will, is negatived as much by the analysis of consciousness as by the contents of the preceding chapters. From the universal law that, other things equal, the cohesion of psychical states is proportionate to the frequency with which they have followed one another in experience, it is an inevitable corollary that all actions whatever must be determined by those psychical connexions which experience has generated—either in the life of the individual, or in that general antecedent life of which the accumulated results are organized in his constitution.

To go at length into this long-standing controversy respecting the Will, would be alike useless and out of place. I can but briefly indicate what seems to me the nature of the current illusion, as interpreted from the point of view at which we have arrived. We will look at it first subjectively and then objectively.

Considered as an internal perception, the illusion results from supposing that at each moment the *ego*, present as such in consciousness (I exclude the implied, but unknown, substratum which can never be present), is

and we were kept some time, as one of the horses would not start. Various plans were tried to overcome its stupidity, but without success. At last the driver directed the conductor to shut the door violently (this is a usual signal for starting). To my great surprise the horse went on at once." *Lond. Hosp. Reports.* Vol. I., 1864, p. 454. Here the once voluntary act of starting after hearing the sound, had become so automatic that an antagonist volition could not prevent it.

something more than the aggregate of feelings and ideas which then exists. When, after a certain composite mass of emotion and thought has arisen in him, a man performs an action, he commonly asserts that *he* determined to perform the action; and by speaking as though there were a mental self, *present to his consciousness*, yet not included in this composite mass of emotion and thought, he is led into the error of supposing that it was not this composite mass of emotion and thought which determined the action. But while it is true that he determined the action, it is also true that the aggregate of his feelings and ideas determined it; since, during its existence, this aggregate constituted his entire consciousness—that is, constituted his mental self. Either the *ego* which is supposed to determine or will the action, is present in consciousness or it is not. If it is not present in consciousness, it is something of which we are unconscious—something, therefore, of whose existence we neither have nor can have any evidence. If it is present in consciousness, then, as it is ever present, it can be at each moment nothing else than the total consciousness, simple or compound, passing at that moment. It follows, inevitably, that when an impression received from without, makes nascent certain appropriate motor changes, and various of the feelings and ideas which must accompany and succeed them; and when, under the stimulus of this composite psychical state, the nascent motor changes pass in actual motor changes; this composite psychical state which excites the action, is at the same time the *ego* which is said to will the action. Naturally enough, then, the subject of such psychical changes says that he wills the action; since, psychically considered, he is at that moment nothing more than the composite state of consciousness by which the action is excited. But to say that the performance of the action is, therefore, the result of his free will, is to say that he determines the cohesions of the psychical states which arouse the action; and as these psychical states constitute himself at that moment, this is to say that these psychical states determine their own cohesions, which is absurd. Their cohesions have been determined by experiences—the greater part of them, constituting what we call his natural character, by the experiences of antecedent organisms; and the rest by his own experiences. The changes which at each moment take place in his consciousness, and among others those which he is said to will, are produced by this infinitude of previous experiences registered in his nervous structure, co-operating with the immediate impressions on his senses: the effects of these combined factors being in every case qualified by the physical state, general or local, of his organism.

This subjective illusion in which the notion of free will commonly originates, is strengthened by a corresponding objective illusion. The actions of other individuals, lacking as they do that uniformity characterizing phenomena of which the laws are known, appear to be lawless—appear to be under no necessity of following any particular order; and are hence supposed to be determined by the unknown independent something called the Will. But this seeming indeterminateness in the mental succession is consequent on the extreme complication of the forces in action. The composition of causes is so intricate, and from moment to moment so varied, that the effects are not calculable. These effects are, however, as conformable to law as the simplest reflex actions. The irregularity and apparent freedom are inevitable results of the complexity; and equally arise in the inorganic world under parallel conditions. To amplify an illustration before used:—A body in space, subject to the attraction of a single other body, moves in a direction that can be accurately predicted. If subject to the attractions of two bodies, its course is but approximately calculable. If subject to the attractions of three bodies, its course can be calculated with still less precision. And if on all sides of it there are multitudinous bodies of various sizes at various distances, as in the middle of one of the great star-clusters, its motion will appear uninfluenced by any of them: it will move in some indefinable way that looks self-determined: it will seem to be *free.* Similarly, in proportion as the cohesions of each psychical state to others, become great in number and various in degree, the psychical changes will become incalculable and apparently subject to no law.

§ 220. To meet objections that have been raised, let me add here some explanations.

If we spoke of Henry VIII. as defying the Pope, and then said that the English King also defied the Pope, there would be a manifest mistaking of words for things. The kingly power we know to be nothing but the permanent name for the power of a person, who is now of one nature and now of another. But in the case of mental government, this confusion between words and things is almost universal. The permanent name for the holder of power, is supposed to imply an entity additional to that implied by the name of the temporary holder of power. We speak of Will as something apart from the feeling or feelings which, for a moment, prevail over others; whereas it is nothing but the general name given to the special feeling that gains supremacy and determines action. Take away all sensations and emotions, and there remains no Will. Excite some of these, and Will, becoming possible, becomes actual only when one of them, or a group of them, gains predominance. Until there is a *motive* (mark the word) there is no Will. That is to say, Will is no more an existence separate from the predominant feeling, than a king is an existence separate from the man occupying the throne.

That the *ego* is something more than the passing group of feelings and ideas, is true or untrue according to the degree of comprehension we give to the word. It is true if we include the body, and its functions; but it is untrue if we include only what is given in consciousness.

Physically considered, the *ego* is the entire organism, including its nervous system; and the nature of this *ego* is pre-determined: the infant had no more to do with the structure of its brain than with the colour of its eyes. Further, the *ego* considered physically, includes all the functions carried on by these structures, when supplied with the requisite materials. These functions have for their net result to liberate from the food, &c., certain latent forces. And that distribution of these forces shown by the activities of the organism, is from moment to moment caused partly by the existing arrangement of its parts and partly by the environing conditions.

The physical structures thus pervaded by the forces thus obtained, constitute that substantial *ego* which lies behind and determines those ever-changing states of consciousness we call Mind. And while this substantial *ego*, unknowable in ultimate nature, is phenomenally known to us under its statical form as the organism, it is phenomenally known under its dynamical form as the energy diffusing itself through the organism, and, among other parts, through the nervous system. Given the external stimuli, and the nervous changes with their correlative mental states, depend partly on the nervous structures and partly on the amount of this diffused energy: each of which factors is determined by causes not in consciousness but beneath consciousness. The aggregate of feelings and ideas constituting the mental *I*, have not in themselves the principle of cohesion holding them together as a whole; but the *I* which continuously survives as the subject of these changing states, is that portion of the Unknowable Power which is statically conditioned in special nervous structures pervaded by a dynamically-conditioned portion of the Unknowable Power called energy. (Compare with § 469.)

PART V.

PHYSICAL SYNTHESIS

CHAPTER I.

A FURTHER INTERPRETATION NEEDED.

§ 221. We are now prepared for dealing with the remaining problem presented by objective Psychology. Though not conspicuous, the *hiatus* between the interpretation we have reached and a complete interpretation, is a deep one; and one which, when first looked into, appears impassable. For there has still to be answered the inquiry—how is mental evolution to be affiliated on Evolution at large, regarded as a process of physical transformation? It is not enough that in the preceding General Synthesis the phenomena of psychical life have been traced up through their objective manifestations, and, along with the phenomena of physical life, have been found to progress in integration, in heterogeneity, in definiteness. It is not enough that, in the Special Synthesis just closed, intelligence has been shown to have the same nature and the same law from the lowest reflex action up to the most transcendent triumph of reason; and that, from first to last, its growth is due to the repetition of experiences, the effects of which are accumulated, organized, and inherited. It may yet be asked—By what process is the organization of experiences achieved? Granting that a survey of the facts proves it to take place; still, no answers are given to the questions—Why does it take place? And how does the transformation which brings it about come within the formula of Evolution in general?

Specifically stated, the problem is to interpret mental evolution in terms of the re-distribution of Matter and Motion. Though under its subjective aspect, Mind is known only as an aggregate of states of consciousness, which cannot be conceived as forms of Matter and Motion, and do not therefore necessarily conform to the same laws of re-distribution; yet under its objective aspect, Mind is known as an aggregate of activities manifested by an organism—is the correlative, therefore, of certain material transformations, which must come within the general process of material evolution, if that process is truly universal. Though the development of Mind itself, cannot be explained by a series of deductions from the Persistence of Force, yet it remains possible that its obverse, the development of physical changes in a physical organ, may be so explained; and until it is so explained, the conception of mental evolution as a part of Evolution in general, remains incomplete.

§ 222. Here, then, the structure and functions of the nervous system, considered as resulting from intercourse between the organism and its environment, form our subject-matter. We have to identify the physical process by which an external relation that habitually affects an organism, produces in the organism an adjusted internal relation.

Of course, it is not to be expected that specific interpretations can be given of the particular structures performing particular functions which fit an animal to its particular conditions of existence. All we can hope is to assign a general cause, which, acting under conditions such as are known to exist, is capable of producing effects like those observed. Let us present in its simplest and most definite form the question which alone admits of an answer.

We have seen the law of intelligence to be, that the strength of the tendency which the antecedent of any psychical change has to be followed by its consequent, is proportionate to the persistence of the union between the external things they symbolize. We have seen that the fulfilment of this law is accounted for if, by inheritance through successive organisms, intelligence grows, as it does in the individual organism, in consequence of the fact that, when any two psychical states occur in immediate succession, such an effect is produced that when the first recurs, there is a tendency for the second to follow it. And now, to complete the solution, we have to ascertain the universal principle to which this tendency is due. In other words, regarding psychical changes as the subjective faces of what on their objective faces are nervous actions, the inquiry before us is—from what general law of the re-distribution of Matter and Motion does it result, that when a wave of molecular transformation passes through a nervous structure, there is wrought in the structure a modification such that, other things equal, a subsequent like wave passes through this structure with greater facility than its predecessor? And—not to evade a still deeper question which immediately follows—is the establishment of nervous communication itself explicable on this same general principle? Are we enabled by it to understand not only how nerve becomes more permeable, but how nerve is formed?

If to these general questions we discover a satisfactory general answer, we shall do all that is needful. If from a corollary to the Persistence of Force, we can legitimately draw the conclusion that, under certain conditions, lines of nervous communication will arise, and, having arisen, will become lines of more and more easy communication, in proportion to the numbers and strengths of the discharges propagated through them; we shall have found a physical interpretation which completes the doctrine of psychical evolution, as set forth in the last two parts. It will be made manifest how the experience of an external relation produces a corresponding internal relation—how, as experience of the external relation become more numerous, the internal relation becomes more coherent—how perpetual repetitions of the one cause indissolubleness of the other—how outer persistences that are almost or quite absolute, establish, in the course of generations, inner cohesions that are automatic or organic; and thus the interpretation of instincts and forms of thought will be assimilated to that of the ordinary phenomena of association.*

* The general doctrine elaborated in the succeeding chapters, was prefigured in the first edition of this work, in a note on page 544—the verbal form, however, being such as I should not now use. I made a more definite statement of it in an article published in the *Medico-Chirurgical Review* for January, 1859.

CHAPTER II.

THE GENESIS OF NERVES.

§ 223. In *First Principles*, Part II., Chap. IX., we found that in all cases, motion "follows the line of greatest traction, or the line of least resistance, or the resultant of the two." We also saw "that motion once set up along any line becomes itself a cause of subsequent motion along that line"—equally when the motion is that of matter through space, that of matter through matter, and that of molecular undulations through an aggregate of molecules.

In the section dealing with nervous actions (§ 79), it was contended that the mode of motion we distinguish as a nervous discharge, conforms to this law. "Supposing the various forces throughout an organism to be previously in equilibrium, then any part which becomes the seat of a further force, added or liberated, must be one from which the force, being resisted by smaller forces around, will initiate motion towards some other part of the organism. If elsewhere in the organism there is a point at which force is being expended, and which so is becoming minus a force which it before had, instead of plus a force which it before had not, and thus is made a point at which the re-action against surrounding forces is diminished; then, manifestly, a motion taking place between the first and the last of these points is a motion along the line of least resistance. Now a sensation implies a force added to, or evolved in, that part of the organism which is its seat; while a mechanical move ment implies an expenditure or loss of force in that part of the organism which is its seat. * * * When there is anything in the circumstances of an animal's life, involving that a sensation in one particular place is habitually followed by a contraction in another particular place—when there is thus a frequently-repeated motion through the organism between these places; what must be the result as respects the line along which the motions take place? Restoration of equilibrium between the points at which the forces have been increased and decreased, must take place through some channel. If this channel is affected by the discharge—if the obstructive action of the tissues traversed, involves any reaction upon them, deducting from their obstructive power; then a subsequent motion between these two points will meet with less resistance along this channel than the previous motion met with; and will consequently take this channel still more decidedly."

In the *Principles of Biology*, § 302, this general proposition was further elaborated. It there became needful to indicate a possible process by which, among other tissues, nerve-tissue arises out of that protoplasm composing the undifferentiated organism. Here, in an abbreviated form, is the argument which was used:—"It is to be inferred that a molecular disturbance in any part of a living animal, set up by either an external or internal agency, will almost certainly disturb and change some of the surrounding colloids not originally implicated—will diffuse a wave of change towards other parts of the organism: a wave which will, in the absence of perfect homogeneity, travel further in some directions than in others. Let us ask next what will determine the differences of distance travelled in different directions. Obviously any molecular agitation spreading from a centre, will go furthest along routes that offer least resistance. What routes will these be? Those along which there lie most molecules that are easily changed by the diffused molecular motion, and which yet do not take up much molecular motion in assuming their new states. * * * Unstable molecules which, in being isomerically transformed, do not absorb motion, and still more those which, in being so transformed, give out motion, will readily propagate any molecular agitation; since they will pass on the impulse either undiminished, or increased, to adjacent molecules. * * * It may be concluded that any molecular agitation set up by what we call a stimulus, will diffuse itself further along some lines than along others, if" the mingled colloids forming "the protoplasm are not quite homogeneously dispersed, and if some of them are isomerically transformed more easily, or with less expenditure of motion, than others; and it will especially travel along spaces occupied chiefly by those molecules which give out molecular motion during their metamorphoses, if there should be any such. * * * As is shown by those transformations that so rapidly propagate themselves through colloids, molecules that have undergone a certain change of form, are apt to communicate a like change of form to adjacent molecules of the same kind—the impact of each overthrow is passed on and produces another overthrow. * * * Is this action limited to strictly isomeric substances? or may it extend to substances that are closely allied? * * * There is reason to suspect that it does. Already when treating of the nutrition of parts, it was pointed out that we are obliged to recognize a power possessed by each tissue to build up, out of the materials brought to it, molecules of the same type as those of which it is formed. * * * If this be a general principle of tissue-growth and repair, we may conclude that it will apply in the case before us. A wave of molecular disturbance passing along a tract of mingled colloids closely allied in composition, and isomerically transforming the molecules of one of them, will be apt at the same time to form some new molecules of the same type, at any place where there exist the proximate components, either uncombined or feebly combined in some not very different way. * * * That is to say, a wave of molecular disturbance diffused from a centre, and travelling furthest along a line where lie most molecules that can be isomerically transformed with facility, will be likely at the same time to further differentiate this line, and make it more characterized than before by the easy-transformability of its molecules."

Referring the reader to the *Principles of Biology* for the details and conclusion of this abridged argument, it may be well to remind him that in the first part of this work, the interpretations of nerve-structure and nerve-function were grounded on a conception which is a corollary from the conception recalled above; and that sundry verifications were there found. We saw that the quantity of effect produced by irritated nerve-fibre, increases with the distance between the place of irritation and the place of discharge; and this accumulation of force we found to be just that which would result from a wave of isomeric transformation through matter of the required kind (§ 19). We saw, too, that the ultimate nitrogenous nerve-threads are severally sheathed in a peculiar substance, which, judging by its unequalled molecular complexity, is less capable than any other known substance of transferring molecular motion, and therefore best fitted to prevent lateral loss of that growing wave of molecular motion which a nerve-fibre transmits. And we further saw that a close analogy exists between this assumed propagation of isomeric change along a nerve-fibre, and certain observed propagations of like changes along fibres of other substances (§ 34). To which let me here add the fact that protoplasm and its derivatives are distinguished by the great number of their isomeric forms, and the great facility with which these are changed by very various agents; so that in regarding a nervous discharge as a wave of isomeric transformation, we are regarding it as one out of the many such transformations which living matter continually undergoes.

§ 224. Another preliminary step remains. We have to observe the possible modes in which a line of nervous communication may be improved. When, through undifferentiated tissue, there has passed for the first time a wave of disturbance from some place where molecular motion is liberated to some place where it is absorbed, the line of least resistance followed must be an indefinite and irregular one. Fully to understand the genesis of nerve, then, we must understand the physical actions which change this vague course into a definite channel, that becomes ever more permeable as it is more used.

Several actions conduce to this result. The first is that already described, by which, along a line of discharge, there is a genesis of the matter most capable of communicating the discharge. Every time an incipient nerve is traversed by another wave of molecular motion, there is apt to be a further formation of the molecules which are isomerically transformed by the wave and pass it on in being transformed. This process acts with continually-increasing power, for two reasons. One is that progressing limitation of the wave to a well-marked line, enables it to produce more decided effects along that line. An illustration will here help us. When a body of water flows over a surface offering no distinct course, it thins out into wide-spread shallows near its margin, where it is almost motionless; and it has but little motion even along its central deepest parts. But if the inundation is long continued, the abraiding action of the current along these central deepest parts where it moves fastest, tends to deepen its channel there more than elsewhere. A secondary result is a retreat of the water from the shallows—the current becomes more concentrated. In proportion as it becomes more concentrated the force of its central part becomes greater still, and the deepening more rapid; which entails a further drawing in of the margins and a further addition to the excavating force. So that the growing definiteness of the current brings a growing power of making its channel quite definite. Now though in the case before us we have not a motion of matter over matter, but a transfer of molecular motion from molecules to molecules, the parallel holds. Any greater effect produced by the transfer along one part of its originally-broad course, similarly tends to concentrate the transfer along this part, and thus to intensify the action which makes this part a precisely-marked channel. A further facilitation results from an absolute increase in the amount of the nervous discharge. The more permeable the line of molecules becomes, the greater becomes the initial quantity of molecular motion it draughts off. As with water, the formation of a definite channel not only makes the transfer easier and adds to the excavating power of the current, supposing its volume be constant, but also (if the reservoir can supply more) augments the volume carried away, which again adds to the excavating power; so the formation of a better line of nervous communication is followed by an increase of the wave that sets out to traverse it, and a consequent increase in the channel-making action. Once more, every addition to the molecular motion transmitted, adds to the effectiveness of each discharge in overcoming an obstacle. Suppose the greater part of its channel has become tolerably permeable, but that at some place in it the colloidal matter is less transformed than elsewhere into the fit type. Then the more the rest of its channel increases in permeability, the more powerful must be the wave of molecular motion brought to bear on the untransformed part, and the greater must be the tendency to transform it. Hence the channel will progress towards a state of uniform permeability.

There is another possible, and I think probable, way in which the passage of a nervous discharge is made easier. The molecules of the peculiar colloid composing a nerve, may be either irregularly arranged or regularly arranged; and if irregularly arranged they will transmit a wave of molecular motion less readily than if regularly arranged. Now when a thread of molecules capable of the required easy isomeric transformation is first formed, the probabilities are infinity to one that adjacent molecules will be unsymmetrically placed with respect to one another—they will not stand in polar order. Molecules that are highly complex and massive, either do not crystallize at all or crystallize with great difficulty. Either their colloidal, non-polar arrangement is a permanent one, or it is one out of which they pass into a polar arrangement very slowly, under special conditions. Nevertheless, molecules of every type have a form of distribution in which their polar forces are in equilibrium. Towards this they must ever tend, however feebly; and towards this every slight molecular disturbance enables them to approach. Hence, if through a line of colloidal molecules wholly out of polar arrangement, there pass successive waves of molecular motion, each will help adjacent molecules towards polar arrangement, or state of equilibrium. Let us consider the concomitants.

To aid our conceptions we will as before (§ 19) take the rude analogy furnished by a row of bricks on end, which overthrow one another in succession. If such bricks on end have been adjusted so that their faces are all at right angles to the line of the series, the change will be propagated along them with the least hindrance; or, under certain conditions, with the greatest multiplication of the original impulse. For when so placed, the impact each brick gives to the next, being exactly in the line of the series, will be wholly effective; but when they are otherwise placed it will not. If the bricks stand with their faces variously askew, each in falling will have a motion more or less diverging from the line of the series; and hence only a part of its momentum will impel the next in the required direction. Now though in the case of a series of molecules the action can be by no means so simple, yet the same principle holds. The isomeric change of a molecule must diffuse a wave which is greater in some one direction than in all others. If so, there are certain relative positions of molecules such that each will receive the greatest amount of this wave from its predecessor, and will so receive it as most readily to produce a like change in itself. A series of molecules thus placed must stand in symmetrical relations to one another—polar relations. And it is not difficult to see that, as in the case of the bricks, any deviation from symmetrical or polar relations will involve a proportionate deduction from the efficiency of the shock, and a diminution in the quantity of molecular motion given out at the far end. But now, what is the indirect result when a wave of change passes along a line of molecules thus unsymmetrically placed? The indirect result is that the motion which is not passed on by the unsymmetrically-placed molecules, goes towards placing them symmetrically. Let us again consider what happens with our row of bricks. When one of these in falling comes against the next, standing askew, its impact is given to the nearest angle of this next, and so tends to give this next a motion round its axis. Further, when the next thus moved delivers its motion to its successor, it does this not through the angle on the side that was struck, but through the diagonally-opposite angle; and, consequently, the reaction of its impact on its successor adds to the rotatory motion already received. Hence the amount of force which it does not pass on, is the amount of force absorbed in turning it towards parallelism with its neighbours. Similarly with the molecules. Each in falling into its new isomeric attitude, and passing on the shock to its successor, gives to its successor a motion which is all passed on if the successor stands in polar relation towards it, but which, if the relation is not polar, is only partially passed on—some of it being taken up in moving the successor towards a polar relation. One more consequence is to be observed. Every approach of the molecules towards symmetrical arrangement, increases the amount of molecular motion transferred from one end of the series to the other. Suppose that the row of bricks, which were at first very much out of parallelism, have fallen, and that part of the motion given by each to the next has gone towards bringing their faces nearer to parallelism; and suppose that, without further changing the positions of their bases, the bricks are severally restored to their vertical attitudes; then it will happen that if the serial overthrow of them is repeated, the actions, though the same as before in their kinds, will not be the same as before in their degrees. Each brick, falling as it now does more in the line of the series, will deliver more of its momentum to the next; and less momentum will be taken up in moving the next towards parallelism with its neighbours. If, then, the analogy holds, it must happen that in the series of isomerically-changing molecules, each transmitted wave of molecular motion is expended partly in so altering the molecular attitudes as to render the series more permeable to future waves, and partly in setting up changes at the end of the series; that in proportion as less of it is absorbed in working this structural change, more of it is delivered at the far end and greater effect produced there; and that the final state is one in which the initial wave of molecular motion is transmitted without deduction—or rather, with the addition of the molecular motion given out by the successive molecules of the series in their isomeric falls.

§ 225. From beginning to end, therefore, the development of nerve results from the passage of motion along the line of least resistance, and the reduction of it to a line of less and less resistance continually. The first opening of a route along which equilibrium is restored between a place where molecular motion is in excess and a place where it is in defect, comes within this formula. The production of a more continuous line of that peculiar colloid best fitted to transmit the molecular motion, also comes within this formula; as does likewise the making of this line thicker and more even. And the formula also covers that final process by which the line, having been formed, has its molecules brought into the polar order which least resists, and indeed facilitates, the transmission of the wave.

§ 225*a*. Some qualifications of the foregoing exposition must now be made. Instead of changing it throughout to meet criticisms, I have thought it best to repeat the exposition as given in the second, third, and fourth editions of this work and then to indicate the needful modifications.

At the meeting of the British Association held in Belfast in 1874, Prof. Clerk-Maxwell objected to the hypothesis that the nerve-current consists of successive waves of isomeric change, on the ground that the implied conception was that of a "heat-machine," and that a heat-machine is impossible in the absence of difference of temperature. In reply, I contended that my hypothesis is not at variance with this law of thermo-dynamics, since it supposes that the falling of each molecule from one isomeric form to another is accompanied by absorption of heat, and that the nerve-fibre, thereupon rendered of lower temperature than the surrounding matters, instantly takes up from them heat sufficient to cause the molecules to resume their previous form: the implication being that the nerve-current is at the cost of the heat yielded by the imbedding tissues. The discussion which ensued failed to draw from Prof. Clerk-Maxwell the admission that my reply was adequate, and failed also to make me understand his difficulty. This difficulty, as since explained to me by Lord Rayleigh, is that, being a lower form of molecular motion, heat cannot reproduce that higher form of molecular motion implied by the hypothesis. Here I have no alternative but to accept the *dicta* of these two distinguished physicists. It is true that the heat supplied by a sitting hen apparently suffices to build up a variety of complex compounds, some of which, as protagon, are more complex than any of those contained in the unorganized materials of the egg; and it might seem a fair inference that such being the case, heat must be capable of raising a molecule of protein from a lower isomeric form to a higher. But I suppose there must be some lack of parallelism between the two cases, and that this rhythmical isomeric change in nerve-fibre implies some further physical process which ultimate physical principles negative.

What qualification then must the hypothesis undergo to render it tenable? Apparently we must conclude that in nerve-fibre, as in the tissues at large, performance of function is accompanied by molecular disintegration, and that fitness for subsequent performance of function is to be gained only by re-integration. The implication would seem to be that the molecular change must be, to some extent, a chemical change; and that each molecule which has undergone modification, has to be repaired by absorption of needful matter from the nutrient liquid with which it is bathed.

This supposition appears congruous with the fact that the axis-cylinder of a nerve-fibre, small in diameter though it is, consists of a bundle of still more minute fibres. It seems not unlikely that such component fibres as have conveyed a wave of nerve-change, and become thereby temporarily incapacitated, have their functions undertaken by another cluster of component fibres, which carry the next wave, and these, again, leave the function to be afterwards performed by a third cluster, and so on: the fibres of the first cluster having meanwhile refitted themselves for activity. If so, there is a parallelism between the action of nerves and the action of muscles; in which last the sets of fibres take their turns of action and rest, while the muscle as a whole continues in a state of contraction.

CHAPTER III.

THE GENESIS OF SIMPLE NERVOUS SYSTEMS.*

§ 226. Careful and extended observations have necessitated changes in the cell-doctrine as originally propounded. The statement that all organisms of sensible sizes are made up of minute nucleated bodies, completely distinct from one another, has to be much qualified.

Among botanists a wide change of view resulted from the discovery that in the tissues of plants the protoplasm within each cell is united to that within adjacent cells by threads of protoplasm which pass through the respective cell-walls: a discovery that at once makes more comprehensible various plant-movements. Implying a kindred structure, Prof. Sedgwick writes:—"It is becoming more and more clear

* In his Inaugural Address to the Section of Anatomy and Physiology, at the meeting of the British Association in 1880, Prof. Balfour, after indicating certain new lights thrown on the evolution of nervous systems, remarked concerning the contents of this chapter:—"These hypotheses of Herbert Spencer, which have been widely adopted in this country, are, it appears to me, not borne out by the discoveries to which I have called your attention to-day." Being, as I considered, bound to accept Prof. Balfour's representations, I was about to change essentially the first part of this chapter, when my attention was drawn to an opinion since published by Prof. Adam Sedgwick, the successor of Prof. Balfour in the same chair at Cambridge. The opinion in question is contained in *A Monograph of the Development of Peripatus Capensis*, p. 49, and is expressed as follows:—"Herbert Spencer's view of the origin of the nervous system may perhaps not be so far from the mark as at first sight appeared." Taking advantage of the recent results of histological researches, I have been led, by the criticism and counter-criticism above quoted, to re-cast the early part of this chapter, and to give the contained hypothesis a more satisfactory form, I think, than previously seemed possible.

every day that the cells composing the tissues of animals are not isolated units, but that they are connected with one another. I need only refer to the connection known to exist between connective tissue cells, cartilage cells, epithelial cells, &c. And not only may the cells of one tissue be continuous with each other, but they may also be continuous with the cells of other tissues" (pp. 47–8).

The revised conception to which we are thus introduced, is that throughout those aggregations of Protozoa by which Metazoa have been formed, there has been an incompleteness of those spontaneous fissions which, if complete, would have multiplied the Protozoa: the units have remained connected by prolongations homologous with pseudopodia. As the members of a compound Rhizopod, say one of the *Foraminifera*, are not wholly cut off from one another, but maintain some continuity of substance through perforations in the septa—as the living units which make up a *Volvox* or a *Raphidiophrys* are held together by threads of protoplasm which traverse their respective limiting membranes; so it appears that segmentation in a fertilized ovum does not absolutely isolate the contained matter of each segment. In the ovum of *Peripatus*, at any rate, which is exceptionally adapted for displaying the early changes, there results a network of protoplasm which unites the cell-masses with one another. And Prof. Sedgwick, saying that in Peripatus "the connection of cell with cell is not a secondary feature acquired late in development, but is primary," leans to the conclusion that "the continuity in the various cells of the adult" is "due to a primitive continuity which has never been broken" (p. 49).

Thus, then, we must conceive of animal tissue as having from the beginning consisted of a matrix of relatively inert substances throughout which there runs a nucleated network of living and active protoplasm.

§ 226*a*. As shown in the actions of a Rhizopod, protoplasm displays at once the properties of nerve and muscle; it conducts and it contracts. These united properties still characterize it when it assumes the form of an imbedded network. That it continues to possess them when permeating vegetal tissues is proved by such actions as those of the Sensitive Plant and the *Dionæa*—actions which show us both the conveyance of a disturbance and the production of movement at a distance. And that the protoplasmic network of animal tissue has the like combined traits we see in such simple types as the *Hydra*.

Observe, next, that these properties are most markedly displayed where the protoplasm exists in an elongated form. If the tentacle of a polype is touched it contracts with tolerable promptness—with greater promptness than the body contracts. Among the oceanic *Hydrozoa* which, floating or swimming, have long pendant tentacles, such as *Diphyes* and *Physalia*, the threads of nucleated sarcode thus trailing behind or hanging down, are quickly drawn up when struck by small creatures serving for prey. These traits are in great measure cause and consequence. Molecular change set up at the end of a thread-shaped portion of substance is necessarily limited to the line formed by the substance. It cannot be lost by diffusion through a large mass like that of the body, but must be concentrated within the channel formed by the sides of the thread.

This much premised, let us now ask what will result in the body of a creature which is as yet but little differentiated?—what will happen to the nucleated network of protoplasm diffused through it? From the general law of the instability of the homogeneous, it is to be inferred that the originally-united properties of protoplasm will not remain the same throughout. We may expect a specialization such as will restrict the contractile power to some parts of it and leave the power of conduction to other parts. How will this differentiation be likely to arise? Suppose the incipiently-organized mass to be from time to time rudely disturbed by passing bodies—How will the effects of the shocks be localized? May we not reasonably say that the parts of the protoplasmic network which become contractile, will be those of which the contraction is least resisted; and, conversely, that the parts which cannot contract without greater resistance will remain conductive only. So far as ascertained, the facts harmonize with this supposition. Muscular fibres first make their appearance as processes of the epithelial cells forming the surface of the body (see Balfour's *Embryology*, vol. II. p. 667); and this is the part in which movement is least resisted, since the inert matter on one side only of the layer, has to be carried along with the contracting elements. Conversely, though the primitive nervous elements, being the recipients of external impressions, first arise on the outer surface, yet the protoplasmic network connected with them, which takes on the function of conducting impressions, soon becomes established below the surface: contraction in this part of the network being opposed by inert tissue imbedding the fibres on all sides, and the assumption of conducting function solely being hence favoured.

A further question now presents itself—By what physical process is the functional relation established between these muscular and nervous elements as fast as they differentiate? There is a not unsatisfactory answer. A portion of tissue which, by disturbance of one or other kind, has been made to contract, is a portion in which molar motion has been produced at the cost of molecular motion: the one implies the other. Contrariwise, a portion of tissue which, by some incident force or stimulus, has been disturbed, but does not undergo contraction, is one in which the molecular motion generated remains free. In the first place, then, there is caused a deficiency, and in the second place there is caused a surplus. Consequently if, between the two, there is any channel through which an equilibrium can be established, a flow of molecular motion through it may be anticipated. Such a channel exists in the protoplasmic network. Hence, when the incipiently-differentiating tissues are disturbed, there will result a draught from the portion which is beginning to act as a sensory organ to the portion which is beginning to act as a contractile organ—a draught which, repeated on each occasion, will, in conformity to the principle set forth in the last chapter, tend ever to make the channel more permeable.

And then, lastly, observe that though there is implied a simultaneity in the production of the deficiency and the surplus in the case described, so that the contraction has already arisen at the time that the stimulus has been received, yet it is inferable that when the connecting channel has become easily permeable, the reception of a stimulus will cause a flow through the channel, and consequent arrival at the contracting part before this has been otherwise disturbed: the result being that the surplus molecular motion received will initiate a contraction. Sensation, or that which corresponds to it, will produce motion through incipient nerves.

§ 227. In many cœlenterate creatures the contractile substance is partly differentiated into muscular fibres; which, however, are distributed in a diffused way. In an *Actinia* the average equality of the forces to which the body is exposed all round, is unfavourable to the formation of distinct muscles and a distinct nervous system. There is nothing which tends to bring the contractility to one place; and therefore nothing which causes the waves of molecular disturbance to take special courses. Probably in a sea-anemone, the incipient lines of nervous discharge are as much diffused as the muscular fibres are diffused. Noting only the fact that the contractile tissue which, when it acts, absorbs molecular motion, becomes differentiated *before* there arise distinct nerve-fibres conveying molecular motion from places where it has been evolved, let us take a hypothetical case fitted to make intelligible the first step in nervous development.

Suppose that the process of continuous gemmation, by which creatures of these low types very generally multiply, is so carried on that the individuals successively produced are interfered with by the colony more on one side than on the other side. Being unsymmetrically conditioned they will become unsymmetrically developed. (*Principles of Biology* §§ 246, 247.) Let Fig. 5 represent a creature of this kind that grows obliquely away from its elder neighbours; and let A B stand for the surface over which the colony is spreading. Then it must happen that

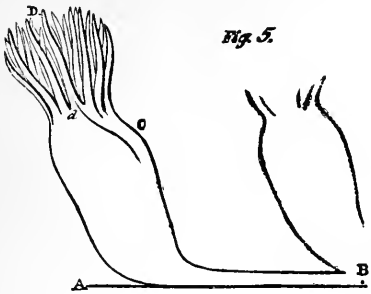


Fig. 5.

when moving objects in the adjacent water, larger than those minute ones serving for prey, come against the creature, first striking its expanded tentacles and then its body, the most exposed part of its body C will be most frequently disturbed. Each time it is disturbed there will be propagated through it that form of molecular change from which contraction results, and there will occasionally be produced more molecules of this same type. (*Principles of Biology* § 302.) That is to say C will become a place where the contractions are relatively frequent and decided, and where contractile protoplasm is greater in amount than elsewhere. What further will happen? Mostly when a collision occurs the tentacles are touched before the body; and, for reasons above given, the propagation of molecular change along them is comparatively rapid. Now at the part C, each evolution of mechanical motion is necessarily accompanied by an absorption of molecular motion. Consequently when from the disturbed end of the tentacle D there has been sent a wave of molecular motion, part of which is absorbed in the contraction of each successive portion of the tentacle but a surplus of which passes on, setting up contractions of the portions below, the final surplus when the wave has reached *d*, will be drafted off to the contractile portion C;

since this, being struck the instant after, and made to contract, becomes a place where molecular motion is absorbed.

But such an action does not constitute a true nervous action. For the stimulus applied at D is not the cause of the contraction at C. The contraction at C is caused by a collision at C; and the discharge from *d* to C cannot take place until after the contraction at C has commenced. Nevertheless, though not a nervous action proper, it may, by frequent repetition, grow into one. If restorations of equilibrium between *d* and C recur often—if they continually take the same route through the network of protoplasm—if this becomes a line of less and less resistance that drafts off the molecular motion with rapidity; then, eventually, when an approaching body touches the end of the tentacle D, the impulse conveyed down it and along the incipient nerve from *d* to C will reach C before the approaching body touches it. Now the contractile colloid at C is capable of having its special molecular transformation set up by various stimuli—by communicated molecular motion as well as by a blow. Hence when a wave of disturbance reaches it before it receives a blow, it will begin to contract in anticipation of the blow. A rude touch at the end of the tentacle D, will, by the shrinking it sets up at C, cause withdrawal of the body from the source of danger.

§ 228. To avoid complications of statement, I have presented this primitive nervous action under a simpler form than that which actually occurs. For the wave of molecular motion has to be conveyed not to a single point but to a portion of contractile colloid having considerable extension, many parts of which simultaneously become places where molecular motion is being absorbed. Hence the wave passing to it will somewhere on its way tend to divide according to the respective tensions towards these respective parts. What will result?

Fig. 6 represents the same general distribution as before, with the difference that the mass of contractile colloid C, is marked in dotted lines, and that at *e* the line of nervous com-

Fig. 6.

munication is shown to take divergent and re-divergent courses towards different parts of C. For this is the structure implied. The same tendency towards restoration of equilibrium which causes the wave to go from *d* to C, will also cause it to distribute itself with tolerable evenness to all parts of C; since to any part which by contracting becomes minus molecular motion, the adjacent parts must ever tend to yield some of their relative surplus, and this must find its way along some line of least resistance.

Let us now ask what will happen at the place *e*. As was shown in the last chapter, the formation of a nerve-thread capable of conveying with facility a wave of molecular motion, implies a definite line pursued by the wave and a definite adjustment of the molecules to that line; and, consequently, such adjustment of the molecules as serves for a wave in one direction will not serve for waves in other directions. At the place *e*, then, where the wave breaks up and its parts diverge, the molecules cannot so arrange themselves as to conduct with facility all parts of the wave. Recurring to our old simile, if a regularly-arranged line of bricks on end comes to a place where there is a cluster of bricks on end, from which diverge other lines of regularly-arranged bricks on end, it is clear that when the first line is overthrown at its beginning and delivers its impulse into the cluster, the bricks forming the cluster must be irregularly overthrown—cannot fall in the same directions with all the divergent lines; and no repetitions of the process can adjust the bricks of the cluster into attitudes that will do this. Hence at the point *e* there will remain some of the nerve-colloid in an amorphous state. Though between the incoming line and the chief outgoing line (if one carries much more of the wave than the rest) there may at last arise a polar arrangement of the molecules, yet this cannot also happen with the minor outgoing lines. But if at *e* the molecules remain unarranged, the wave of molecular motion brought there will be checked; and by as much as it is checked will tend to cause decompositions among the unarranged molecules. As when bricks placed askew fall against one another, their angles are more liable to damage than the angles of bricks placed symmetrically; so a non-polar arrangement of the molecules subjects them to destroying forces which they are saved from by a polar arrangement. Now if decomposition occurs at *e*, additional molecular motion must be disengaged; so that along the outgoing lines there will be discharged an augmented wave. Thus there will arise at *e* something having the character of a ganglion-corpuscle.

That the structure represented is like no known structure, is true. The most conspicuous deviation from fact is in the wide spreading of the lines between *e* and C. And it may be asked—How does their divergence, which appears a necessity of the argument, become so modified as to correspond with the observed distribution? I reply that though the process of direct equilibration will not change this distribution in the required way, it can be so changed by the process of indirect equilibration. (*Principles of Biology* § 164.) When in the course of further evolution neighbouring parts acquire distinct structures, fibres occupying so much space as those between *e* and C will be in the way. An individual in which the lines as they leave the point *e* do not diverge so widely, will therefore have an advantage. And gradually, by survival of the fittest, there will result a type that has these once divergent fibres concentrated into a bundle, the members of which part company only when they arrive at C.

A more serious objection may be raised. The processes given off by ganglion-cells do not ordinarily continue onwards as fibres that end in muscles, in the way implied. The hypothesis as above sketched out, is at variance with the drawings of the biologist. But this seemingly fatal objection may, I think, be satisfactorily met.

§ 229. For there remains to be introduced a complication which I have, for simplicity sake, omitted; and this complication implies a structure that corresponds with fact.

Throughout the exposition we have attended only to the effects caused by the recurring excitations of a single tentacle; and the nervous structure described could arise only in a case of this imaginary simplicity. In reality the excitations are received by many tentacles, each of which sends a wave of disturbance to all parts of the contractile mass C. It does not follow that for every tentacle there must be formed an independent set of nervous connexions like that shown above. Though each afferent fibre will need some place of divergence *e*, yet from each such place of divergence, it is not needful to have a separate nerve-fibre to each of the separate parts of C that have to contract simultaneously. On the contrary, it is inferable that as for each afferent fibre there will be some place of divergence *e*, whence its wave of molecular motion begins to distribute itself; so, for each efferent fibre communicating with each part of C, there will be an analogous place of convergence, where all the portions of waves going to that part will unite. That the nature of the required structures may be clearly conceived, let us first illustrate, diagrammatically, the needful connexions. In Fig. 7, let A stand for half a dozen afferent fibres, while the dots at *a* stand for the points of divergence that arise as above explained. Then if, in the muscle to which the wave is distributed, there are half a dozen contrac-

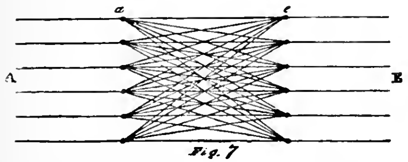


Fig. 7

tile parts to be independently supplied, it is manifest that instead of an independent fibre diverging from each of the points *a*, and running to each of these half-dozen contractile parts, the same end will be achieved if there are half a dozen efferent fibres E, setting out from so many points *e*, which severally receive fibres from all the points *a*. Such an arrangement will indeed be more efficient; since along a fibre which conveys a larger wave, composed of many smaller waves, there will arise a greater facility for transmission than would arise along fibres that conveyed the smaller waves separately. A still simpler system of connexions will serve equally well, or—for reasons like those just assigned—still better. To bring any one of the points *a* into connexion with all the points *e*, there does not need a separate fibre all the way to each. The arrangement shown in Fig. 8, or that shown in Fig. 9, will suffice.

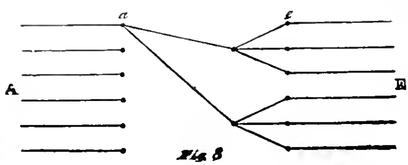


Fig. 8

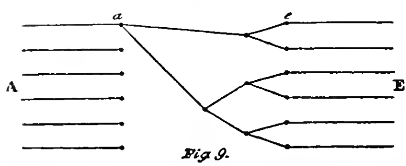


Fig. 9.

Nor must even this more integrated set of connexions be repeated in full for each of the points *a*. In Fig. 10, each point *a* is joined with every point *e*, by a much smaller number of fibres. And since the fibres in this system will be more used than those in any other system, they will become more permeable channels.

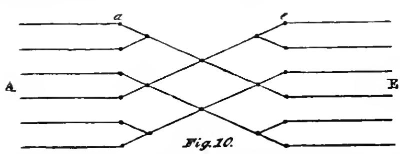


Fig. 10.

Will this kind of structure result from the convergence and divergence of waves of molecular motion following lines of least resistance? We may infer that it will. If to some point *a* in Fig. 9, there has been brought by the afferent fibre from a tentacle a wave of molecular motion; if all the points *e* are the beginnings of efferent fibres severally ending in separate portions of a contractile mass, which by contracting has just become a place where molecular motion is absorbed; if, therefore, between this point *a* and all the points *e*, there arise molecular tensions; then the restoration of equilibrium will be effected by waves of molecular motion which, following a common route for some distance, will break up and diverge on approaching the points *e*—the numbers and positions of the places of divergence being determined by local conditions. Further, if from another of the points *a*, a wave has similarly to find its way along lines of least resistance to all the points *e*, it will do so by passing into some near point of this same plexus. So that between all the points *a* and all the points *e*, there will be produced numerous places of converging and diverging communication; each of which, for reasons above assigned, will be a place containing unarranged and unstable molecules of nerve-matter, liable to be decomposed when disturbed, and to pass on in increased amounts the waves that disturb them.

Now if instead of the regularly arranged lines and points, we conceive lines and points irregularly arranged; and if instead of the half-dozen afferent fibres and as many efferent fibres, we suppose a score or more of each (which we must do to correspond with even the simplest observable cases); and if we proportionately complicate the connecting plexus; we shall have something like a ganglion. Fig. 11 represents such a structure. That it is less intricate than an actual ganglion is what might be expected. The conditions presented by a mass of

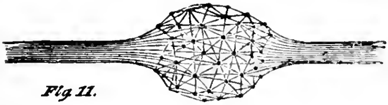


Fig. 11.

protoplasm out of which a ganglion is evolved, are sure to cause great irregularities; and it is not difficult to see that in the course of its evolution, there are likely to arise many incipient lines of connexion which do not develop further because others have superseded them. The agreement between inference and observation is, I think, as close as we can reasonably look for.

It may, indeed, be objected that an actual ganglion differs from this hypothetical ganglion in a more serious way—in not displaying a definite network. The microscope discloses an entangled maze of fibres, cells, and branched processes, that are not formed into a distinct plexus of connexions. To this my reply is, that though I have thus far, for the sake of clearness, spoken of these structures as definite, it is not needful that they should be visibly so. A network of lines of least resistance, is alone requisite; and it may be in part so formed as to be visible and in part so unformed as to be invisible. This qualification must be borne in mind as applying throughout the chapters that are to follow.

§ 230. Let me before closing dispose of a remaining objection. A critical reader may ask—How can a state of molecular tension between two places separated by a great mass of amorphous organic substance, cause transmission along a definite line that divides and sub-divides in the way described?

Doubtless such a process is not easy to imagine under the conditions we are apt to assume. But the apparent difficulty disappears when, instead of the conditions we are apt to assume, we take the conditions which actually occur. The error naturally fallen into is that of supposing these actions to go on in creatures of considerable bulk; whereas observation warrants us in concluding that they go on in extremely small creatures. The type of nervous system approaching nearest in simplicity to the hypothetical one described, we find among the *Polyzoa*—creatures of almost microscopic minuteness. The total length of an individual *Polyzoon* is from a 40th to a 20th of an inch; and if we set down the distance from the roots of the tentacles to the nearest point of the muscle at a 100th of an inch, we shall be much beyond the mark. When the scale is thus immensely reduced, the physical processes described become comprehensible. The thickness of protoplasm through which these restorations of equilibrium are effected being recognized as about the thickness of stout paper, it is no longer difficult to conceive the molecular tensions, and transmissions of molecular motion, to take place in the way alleged, with the inferred results.

The structure described having been first formed on this extremely small scale, admits of eventual enlargement to any scale. Conducing to the preservation and growth of the individual; inherited by progeny capable from the aid it yields of growing still larger; and bequeathed with its accumulated increments of size and development to successively higher types, that spread into better habitats and adopt more profitable modes of life; this mere rudiment may, in course of geologic epochs, evolve into a conspicuous nervous apparatus possessed by a creature of large size. And so by this slow indirect method there may be established lines of nervous communication where direct establishment of them would be impossible.

Finally, it may be well to remind the reader that the argument does not necessitate the assertion that the primitive nervous system was formed in this particular way. The essence of the argument is, that to some place of greatest and most frequent contraction, lines of discharge will be formed from places habitually touched before this contraction is set up; and the case I have chosen is one which lent itself most readily for explanation—not one therefore asserted to be actual. With this *caveat* let us now pass from the simplest case to more complex cases.

CHAPTER IV.

THE GENESIS OF COMPOUND NERVOUS SYSTEMS.

§ 231. When contemplating the incipient differentiation of the psychical life from the physical life (§ 140), it was pointed out that the special senses arise through local modifications of nutrition caused by the special agents responded to. In some of the lowest animals the semi-transparent body is coloured green, red, or brown, by scattered portions of a matter akin to the colouring matter of plants; and the sensitiveness of these creatures to light is doubtless due to the assimilative actions which light sets up in this matter. Higher animals also habitually contain pigment, in cells and scattered granules; and though these are not limited to the superficial tissue, they are ordinarily most abundant in it. Of course the nutrition of deep-seated portions of pigment goes on in the absence of light. But though light is certainly not the only cause of the nutrition of pigment, and perhaps not the chief cause, there is evidence that it is *a* cause; since pigment-grains near the surface commonly increase in size or number or both when much exposed to light. At any rate, we may safely say that in some kinds of pigment produced in animal tissue, light produces marked molecular changes.

Now the rudimentary eye consists of a few pigment-grains under the outermost dermal layer; and hence we may infer that rudimentary vision is constituted by the wave of disturbance which a sudden change in the states of these pigment-grains propagates through the body.

How such pigment-grains become concentrated in the particular places they may most advantageously occupy we need not consider at any length. Other things equal, they will develop most where most light falls, and where, consequently, variations of light caused by adjacent things are strongest; and since a close cluster of pigment-grains when affected, will send through the body a more efficient wave of disturbance, natural selection will further the concentration—there will be a survival of individuals in which the approximation is greatest, ending in the formation of an integrated patch.

The pre-existence of a simple nervous system, akin to that described in the last chapter, being assumed, let us consider what will happen when incipient vision is added.

§ 232. Suppose *f*, Fig. 12, to be the cluster of pigment-grains constituting the rudimentary eye. And suppose that from these pigment-grains, when changed by variations in the amounts of light falling on them, there have been propagated waves of disturbance into the mass of organism. Then wherever these waves eventually go, there will arise behind these pigment-grains at *g*, a plexus of fibres and ganglion-cells. For reasons such as were given in § 229 the separate waves setting out from the separate disturbed pigment-grains, and pursuing lines of least resistance, will quickly unite; and there will result a cluster of junctions occupied by unstable nerve-matter, whence the aggregate wave will direct itself inwards.

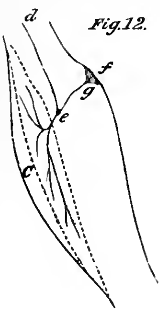


Fig. 12.

To what place will it tend? As before, to the place where molecular motion is being absorbed. If immediately after molecular motion is liberated at *f*, molecular motion is taken up in the muscle C, a molecular tension will arise between *f* and C; and motion along the line of least resistance will result. Which will be the line of least resistance? Already there has been formed a line of easy transmission from the tactual organs to the muscle, along the line *d* to C; and, other things equal, the line of least resistance from *f* to C will be one of which this pre-existing channel forms a part. Hence the tendency will be for the wave of molecular motion to take its course from *f* through the underlying plexus *g* to the pre-established ganglion at *e;* and gradually to form a connecting fibre.

What will be the functional effects of this? So long as the nervous communication is incipient, contraction must be set up in the muscle C, *before* molecular motion disengaged at *f* can cause a state of tension between *f* and C, and therefore an impression on the rudimentary eye will not produce a contraction. The only advantage derivable from such a structure in this early stage, would seem to be that of increasing the amount of contraction otherwise initiated. But as soon as the channel for the transmission of molecular motion from *f* to the ganglion *e* becomes tolerably permeable, the molecular motion disengaged by an impression at *f*, finding its way along this channel, may reach the muscle before the molecular motion set up by touch can reach it; and a consequent contraction of the muscle will withdraw the body in anticipation of touch—the creature will retreat as though alarmed by the approaching object.

§ 233. A nervous system of the type described in the last chapter, or even a nervous system a stage more complex in type, like that just described, can effect none but the simplest adjustments. Small extensions of the correspondence in Space and in Time are alone achievable by it. Muscular contraction is produced by a certain strength of impression on the tentacles, whatever be the nature of the body striking them or the direction in which it is moving. Similarly, the rudimentary eye can do no more than convey to the muscle the impression caused by a change in the quantity of incident light; no matter whether that change be caused by a small body close to or by a large one far off, and no matter whether the motion of the body is or is not such as will presently cause a collision. Nervous systems of these kinds can bring about no special adjustments of the inner acts to special directions and distances of outer objects. Let us consider what further complications will initiate such further adjustments.

More muscles than one are obviously pre-supposed; otherwise the motion can vary in amount only. And there are obviously pre-supposed more than one place of independent stimulation; otherwise not more than one kind of impulse to contraction can be given. If all the tentacles are similarly connected with the same muscle, or if the channel of communication which each pigment-grain in the eye-speck has with the muscle is like that which every other has, there can be no qualitative distinctions among stimuli, and therefore no specialized motions. A simple locomotive creature (moved of course by muscles and not by cilia) fulfils the requisite conditions. Let us suppose one that is, like most locomotive creatures, bilaterally symmetrical—one having two rudimentary eyes and the two muscles, or sets of muscles, which the locomotion of such creatures implies. Suppose that in Fig. 13, *a* and *b* are the nerve-threads coming from the two rudimentary eyes to the ganglion *e*; and that through this, each of these threads is connected with all the threads in each of the two bundles *d* and *f*, running to the muscles G and H. Setting out with the least differentiated structure, we will assume that by means of the plexus at *e*, each afferent fibre is similarly connected, and equally well connected, with each bundle of efferent fibres. What will in such case happen? The stimuli continually received through the eye-specks as the creature moves through the water, will act indifferently, and equally, through the two

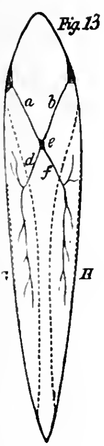


Fig. 13

motor bundles on the two sets of muscles—the alternating contractions of these supplying an instance of the rhythm inevitably generated by antagonistic energies. Only one specialization of the movements will be effected. So long as the changes in the visual stimuli arising from objects which the creature passes, or which pass it, are moderate, the muscles will be excited to moderate contractions. But the approach of a large object, causing sudden and strong impressions on the rudimentary eyes, will send to the muscles sudden and strong discharges, making them violently contract so as to produce a dart—a dart which, though made at random, will usually decrease the chance of being caught, if the approaching body is a predatory animal. But now, however much alike the connexions of the two afferent fibres with the two bundles of efferent fibres may have originally been, it must happen in virtue of the universal law of the instability of the homogeneous, that they will become in some, or rather in most, individuals of the species, slightly unequal. Let the cells, processes and fibres of the ganglion *e*, be congenitally developed in such ways that the fibre *a* has somewhat easier communication with the bundle *d* than with the bundle *f*, or *vice versâ*; and let the connexions of the fibre *b* similarly deviate from complete equality. The effects on ordinary locomotion and on the motion of escape just described, will be insignificant; but there will occur under certain circumstances modified motions of great significance. Suppose that on the side A, an adjacent small object produces in the eye-speck, and sends through the optic fibre, a moderate disturbance. If the connexions of this fibre with the efferent bundle *f* are better than its connexions with the efferent bundle *d*, the muscle on the opposite side of the body will contract most; and the body (supposing it to bend like that of a fish) will be turned *away* from the object which produced the impression. If, contrariwise, its connexions with the bundle on its own side are the best, the body will be turned *towards* the object. Now in many cases the object is one that will serve for food. If, then, this congenital variation in the nervous connexions is such that a moderate stimulus on the eye-speck makes the body turn away from the object yielding the stimulus, the individual will lose rather than gain by the incipient vision; and will therefore disappear. A contrary variation of structure, entailing a contrary effect, will conduce to the welfare of the individual on every occasion when the object towards which the body is turned is food. Each discharge thus sent in excess towards the one set of muscles, will increase the relative permeability of the one set of channels over the other; making the one-sidedness of the next discharge greater still. And since the more decided this tendency becomes the more decidedly the welfare of the individual will be furthered, the creature's life will, on the average of cases, be longer, and the number of progeny left will be greater than is usual in the species. I need scarcely add that among descendants inheriting this modification, functionally increased during the entire life of the parent, the same causes will insure not simply continuance of it but progressive development.

§ 234. A further step may now be taken. The advantages derivable from rudimentary eyes such as are above supposed, will increase as the eyes are evolved, whether in size or in structure. A larger sensitive area will, other things equal, render the creature impressible by smaller objects and by remoter objects, thereby conducing to its welfare; so that survival of the fittest will favour the growth of visual spots made up of numerous sensitive elements. As this multiplication of sensitive elements progresses the ganglionic plexus underneath the eye-speck will develop, and there will fall an additional amount of function on the fibres connecting it with the central ganglion. This increase of function may entail either increased thickness of these fibers or increased number of them. The one will arise from inheritance of functionally-produced modifications. The other will arise from inheritance of incidental variations; since we have clear proof that in a cluster of homologous parts there occasionally arises a member in excess of the normal number. Assuming that a bundle of nerve-fibres connecting the enlarged eye with the central ganglion has been thus established, let us ask what will happen. From the instability of the homogeneous it follows, as before, that however completely alike may at first have been the connexions of these fibres with the different parts of the central ganglion, their connexions cannot remain alike. And, as before, it is clear that while some variations in their connexions will affect the movements of the creature favourably others will affect them unfavourably. What are the favourable variations likely to be? If over the visual surface, now composed of a considerable number of sensitive elements, the transparent epidermis has, by survival of the fittest, acquired that convexity usually observable, the impressions received will fall on the whole patch of sensitive elements only when the objects producing them are opposite to the patch—an object much in advance or behind, much above or below, will cast a vague image on one portion of the patch only. Hence if the fibres composing the afferent bundle are not related with absolute equality to all parts of the nervous plexus underlying the patch of sensitive elements (and mere differences of position must entail inequality) it will happen that when, out of the patch of sensitive elements, one group is affected more than the rest, some members of the afferent bundle will carry larger waves of molecular disturbance than the rest. In cases where the muscular system consists, as supposed in the last section, of but two contractile masses capable of acting only as wholes, this somewhat increased heterogeneity of the *recipio-motor* structures will produce no definite effects. But it is an inductively-established fact that there frequently occur variations in the numbers and attachments of muscular bundles: even in so specific a type as the human, such variations are not uncommon. Supposing, then, the muscles have here been modified somewhat in the direction of multiformity, a further specialization of movements becomes possible. For a discharge carried more largely by some fibres of the incipient optic nerve than by others, will, on arriving at the central ganglion, diffuse itself not quite in the same way as one brought by all the fibres in equal amounts. Hence two somewhat different discharges taking somewhat unlike courses through the central plexus of fibres and cells, and issuing in their multiplied amounts through a bundle of efferent fibres, will severally affect this in diverse ways—some fibres of the bundle taking more of the one discharge and some more of the other. So that if the masses of contractile substance to which this bundle of efferent fibres is distributed are capable of any separateness in their actions, the two discharges will work on them unlike effects, and the motions produced will not be the same. Now the differences in the produced motions, relatively to the objects causing these special impressions, are almost certain to be advantageous or disadvantageous. And, as before, the structures producing motions that are on the average advantageous will conduce to the long life of the individual; will be developed by their repeated actions during this long life; and will be bequeathed with some functionally-produced improvements to posterity.

§ 235. It is not, I think, difficult to see that the same principles continue to hold; and that through successive small stages of analogous kinds, nervous systems may go on complicating. Let us glance at the processes that are likely to occur in a central ganglion that receives and sends out many compound bundles of nerve-fibres.

As implied by what has been said above, when compound afferent bundles become channels of communication from sense-organs severally composed of many separate elements, the discharges they carry into the central ganglion become very variable in composition, and diffuse themselves through its plexus in waves that are never twice exactly alike. The fibres composing the optic nerve, for example, receive different sets of stimulations according to the size of the object, its form, its direction, its distance. Consequently after a well-established reflex connexion has been formed between the visual impression given by a certain kind of prey in a certain position, and the muscular adjustment required to seize such prey, it will happen that the excitement of the muscles must be preceded by, and accompanied by, numerous other excitements. For while there are going on those relative motions that end in bringing the prey to the position which calls forth the reflex action, many changing sets of impressions are being made on the optic fibres—some of them conducing to the approaching reflex action and some of them conducing to other actions. Hence in the central ganglion, numbers of fibres and cells become nascently excited before a certain group of them become excited in such way as to cause the appropriate discharge to the muscles. Now the nascent excitations so caused are not lost: they nascently excite multitudinous efferent fibres belonging to various bundles; and through them throw various muscles into states of partial tension. Here, then, is an ever-present opportunity for further specialization of the correspondence. Suppose, for instance, that the reflex action above described is well adjusted to catching a special object seen in a special position, but that no means exists of so modifying the reflex action as to allow for the motion which the object has when it reaches this position. What will happen? As the object approaches this position from different directions, its image will travel over different sets of retinal elements. In passing over any particular set it excites in succession certain groups of optic fibres, certain clusters of fibres and cells in the central ganglion, and through them nascently excites many efferent fibres with the muscles they supply. The motions that will be gone through when the reflex action takes place, are sure to be somewhat modified by these states of tension previously given to muscles not immediately concerned. The modification may or may not tend to compensate for the motion which the object had when it reached the point where reflex action was set up. But if, by tending to compensate for this motion, the modification is beneficial, the structure producing it will be further developed; and, as before, will be established as an additional adjustment of inner relations to outer relations.

Before proceeding let us note, as bearing on the interpretations given in preceding parts of this work, as well as on interpretations about to be given, that, as above understood, each of these adjustments of inner to outer relations which eventually becomes automatic, passes through stages in which it is not automatic. It begins as a slight tendency for an impression or impressions to excite some muscle or muscles more than the rest. During this stage the passage of the disturbance through the chief nervous centre is slow, hesitating, irregular. The sense-impressions being an appreciable time in the nervous centre before they produce partial motor excitements, remain present there as sense-impressions; and are then the equivalents of what, in higher creatures, we call sensations. Similarly, the nascent motor excitements are the equivalents of what, in higher creatures, are the ideas of the contractions to be produced. Gradually as, by repetition in the individual and in the succession of individuals, this additional connexion between impressions and motions becomes more definite, and the sequence more rapid, that link in it which is either consciousness or the homologue of consciousness, becomes shorter, and the process passes into the purely automatic.

CHAPTER V.

THE GENESIS OF DOUBLY-COMPOUND NERVOUS SYSTEMS.

§ 236. When instead of nerves of touch proceeding from a dozen or a score of tentacles, we have to deal with multitudes of such nerves proceeding from all parts of the skin—when instead of a simple eye, or an eye containing but few retinal elements, we take an eye having a retina made up of thousands of elements, each of which yields a separate impression—when bundles of afferent fibres from complex organs of hearing, taste, and smell have to be taken into account—when the stimuli carried in ever-varying amounts and combinations through these *recipio-motor* structures have to be traced in their effects upon similarly-compounded *dirigo-motor* structures; explanations of the kind attempted in the foregoing pages become very difficult if not impossible. But though we cannot hope to interpret specifically the higher complications of nervous development, we may hope to form some general idea of the ways in which the processes traced thus far may work out results still more involved. To facilitate the formation of such general idea, it will be well to contemplate afresh the characters of the evolution we have followed thus far—changing somewhat the point of view, re-inforcing some of the conclusions reached, and developing others a stage. We shall then be better able to see where further evolution along the same lines is likely to carry us.

§ 237. So long as there exists but a single afferent nerve and a single muscle supplied by the accompanying efferent nerve, external stimuli will produce but one kind of action, varying only in degree. Even when the epi-peripheral impressions are received at any or all of numerous points, such as the ends of tentacles, it must still happen that while the motor apparatus remains quite simple, no modifications in the creature's adjustments can be made beyond the greater or less promptness and strength of the induced contractions.

Such small change as a bifurcation and double insertion of the muscular bundles, makes possible some difference in the kind of effect consequent on difference in the kind of stimulation. And as the nervo-muscular system becomes more complex, it becomes possible for various unlike sets of epi-peripheral impressions to produce various unlike combinations of muscular actions.

But this compounding of stimuli results in the appropriate compounding of movements, only on condition that the nervous centres have become proportionately compounded. The required compounding of them is in principle this:—The connexions of their fibres must be such that when any set of external relations to which the acts are to be adjusted, has been impressed on the senses, the special cluster of stimulations produced, being carried along various afferent nerves, is, in the central plexus, so re-distributed that, in passing out again, it discharges itself through particular sets of motor-fibres in particular proportions.

Every further re-distribution of this kind implies additional places for convergence and divergence of the nerve-waves—additional ganglionic corpuscles. If a certain group of incoming fibres brings nerve waves bearing certain proportions to one another, the appropriate group of outgoing fibres cannot have its components affected in the requisite degrees unless there exists between the two groups a duly adjusted set of convergent and divergent channels, differing in part from all other sets. A general diffusion through the plexus could cause nothing but a general muscular excitement; and a special diffusion ending in discharges that are special in their directions and quantities is impossible unless by the intermediation of a special structure that is definite in proportion as the co-ordination is definite.

As the case has been thus far stated, there can arise no such more specialized or more complex muscular action following the appropriate compound impression, unless through some favourable variation in the structure of the ganglionic plexus. But eventually a new cause of development comes into play. There comes a stage at which adjustments of inner to outer relations may not only be indirectly established by the survival of individuals having favourable variations; they may also be directly established by the inheritance of functionally-produced changes. And the direct establishment of them becomes active when there exists a consciousness sufficiently developed to perceive the connexion between a muscular act and its immediate effect; and when the creature is thus rendered capable of making slight modifications in its acts, of establishing these modifications as habits, and of causing correlative modifications in its nervous centres.

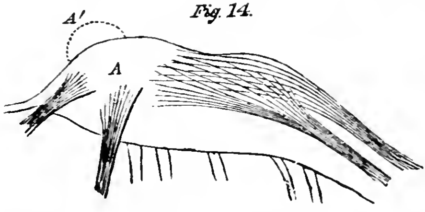
Before this process can be understood, it must be premised that as nervous structures become more complex and more integrated, the network of their connexions becomes so close that every special muscular excitement is accompanied by some general muscular excitement. Along with the concentrated discharge to particular muscles, the ganglionic plexuses inevitably carry off a certain diffused discharge to the muscles at large; and this diffused discharge produces on them very variable results. Suppose, now, that in putting out its head to seize prey scarcely within reach, a creature has repeatedly failed. Suppose that along with the group of motor actions approximately adapted to seize prey at this distance, the diffused discharge is, on some occasion, so distributed throughout the muscular system as to cause a slight forward movement of the body. Success will occur instead of failure; and after success will immediately come certain pleasurable sensations with an accompanying large draught of nervous energy towards the organs employed in eating, &c. That is to say, the lines of nervous communication through which the diffused discharge happened in this case to pass, have opened a new way to certain wide channels of escape; and, consequently, they have suddenly become lines through which a large quantity of molecular motion is drawn, and lines which are so rendered more permeable than before. On recurrence of the circumstances, these muscular movements that were followed by success are likely to be repeated: what was at first an accidental combination of motions will now be a combination having considerable probability. For when on such subsequent occasion the visual impressions have produced nascent tendencies to the acts approximately fitted to seize the object, and when through these there are nascently excited all the states, sensory and motor, which accompany capture, it must happen that among the links in the connected excitations there will be excitations of those fibres and cells through which, on the previous occasion, the diffused discharge brought about the actions that caused success. The tendency for the diffused discharge to follow these lines will obviously be greater than before; and the probability of a successfully modified action will therefore be greater than before. Every repetition of it will make still more permeable the new channels, and increase the probability of subsequent repetitions; until at length the nervous connexions become organized.

One other general fact must be insisted upon. As was pointed out at the close of the last chapter, advancing complexity of nervous organization necessitates an increasing quantity of excitations that do not cause motions. A creature in which the compound impression produced by a special object occupying a special position, arouses the muscular actions effecting capture of the object, is a creature which, by implication, perpetually receives other compound impressions from objects occupying other positions. Each passing thing, as well as every thing passed, sends into its nervous centres variously-combined waves of disturbance, which course through their fibres and cells in ever-varying combinations, and which, having no special connexions with special motor adjustments, simply diffuse themselves without any more specific effect than that of augmenting the general discharge to the vital organs and muscular system at large. These are what, under their subjective aspects, we call feelings and ideas. And, manifestly, the more extensive and more intricate the central plexus grows, the more *detached* may these become from the actions—the more may the impressions produced by things and relations reverberate through the nervous system—the more may there arise trains of thought.

§ 238. Thus much premised, let us try to conceive how compound co-ordination passes into doubly-compound co-ordination. A broad contrast exists between the two; and we shall find reasons additional to those before given (§ 22) for assigning the function of doubly-compound co-ordination to the highest nervous centres.

Let Fig. 14 represent, diagrammatically, the chief nervous centre, now considerably evolved, to which afferent fibres bring all orders of epi-peripheral feelings; and from which efferent fibres carry to the muscles, the stimuli producing their appropriately-combined

Fig. 14.



contractions. And suppose that while other parts of it have for their functions the co-ordination of those epi-peripheral feelings which are least relational, the part A co-ordinates the most relational feelings with one another and with the appropriate motions. Or, to speak specifically, suppose that A is the part of the central plexus where the compound visual impressions joined with the compound impressions from the eye-muscles, are brought into adjusted relations with those combined muscular feelings and accompanying feelings of touch which are implied by actions of the limbs under guidance of the eyes. Then this part will be the one to which are brought the most involved clusters of feelings in ever-varying proportions through multitudinous fibres; and one from which issue through multitudinous fibres in ever-varying proportions the most complicated motor impulses. By implication, each special adjustment of the muscular motions to the visual impressions must have in this part its co-ordinating plexus of converging and diverging fibres with their points of junction—a plexus which, while having many elements in common with the plexuses that effect other co-ordinations, must have some elements peculiar to itself. Whence it follows that in proportion as these special adjustments become more numerous, there must be a multiplication of the elements peculiar to each. Consequently, if some one group of these co-ordinating plexuses takes on a relatively great development, in answer to the relatively immense sphere for new adjustments which certain environing conditions furnish, we may expect one part of this region A, to become protuberant, as at A′. And if these multitudinous new co-ordinating plexuses, growing continually more involved as they grow more numerous, admit of accumulation without limit, we may expect a growth of this protuberance. We shall soon see that these suppositions and inferences are paralleled by facts.

§ 239. Visual impressions and their concomitants are co-ordinated with muscular actions and their concomitants in two ways—the one direct, the other indirect. The direct co-ordinations include such as are possible to a creature by changing the relative positions of its parts without changing its position in space. The indirect co-ordinations include such as are possible only by changing its position in space as well as changing the relative positions of its parts. Let us contrast these two orders.

Without moving from the spot on which I stand, I can explore very completely all things within reach of my hands; and the combined sets of feelings I get have a certain distinctive character of great significance. From each of these things I can derive, *simultaneously*, four clusters of sensations—those it yields my retinæ, those which come from the specially-adjusted muscles of my eyes and head, those which come from the muscles of the arm and hand by which I lay hold of it, and those given me by its contact with the skin of my fingers. The order of co-ordinations which have this important character in common, falls into two genera. One extensive genus of quadruply-clustered sensations I get by exploring the surfaces of my body and limbs. I can adjust my eyes so as to see my hands while they move over my feet; I can use one hand to examine tactually the other hand and arm, and can observe with my eyes, as well as feel with my muscles, the movements I am making. The distinctive trait of quadruply-clustered sensations of this genus, is that each of them contains two sets of tactual sensations—one set coming from the parts touched and the other from the parts touching them. Indeed we may say that they are thus characterized by being quintuply-clustered. A much more extensive genus, distinguished by severally containing only a single tactual cluster, I get from all the objects that exist within a range of three feet or so on each side and in front, as well as above and below. I can stoop down to touch a thing lying near my feet and see that I touch it. Without changing my place, I can successively raise my hand to take down my hat, grasp an umbrella-handle, touch the back of a hall chair, lay hold of a letter waiting for me. Each of these acts gives me a special group of impressions of colour and form, a special group of muscular feelings from the muscles of the eyes and head, a special group from the muscles of the arm and hand, a special group from the skin of the fingers; and performance of each act implies special co-ordination of the special groups. Thus the region of space occupied by my body and by things immediately around it, furnishes numerous compound clusters of sensations, severally having the peculiarity that their components can *co-exist in consciousness.* Within this range the conditions are such that an object which yields me groups of feelings through the eye and through the eye-muscles, may, if I go through a certain series of muscular feelings, be made to yield me a group of tactual feelings joined with a group of feelings of muscular tension; and these additional groups may be brought into juxtaposition in consciousness with the first groups, *without these first groups being in any degree changed.*

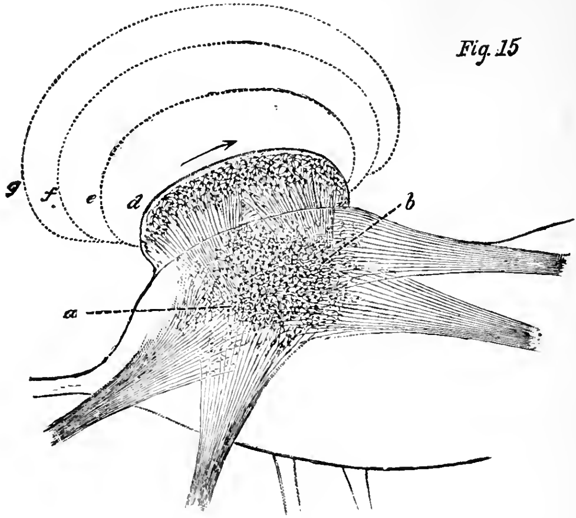
This immense order of co-ordinations is not absolutely demarcated from the far more immense order to which we shall immediately pass: there is a border region common to the two. While I keep my feet and body quite fixed, there is a definite limit to the range of my hands and therefore to the regions within which objects can yield me clustered feelings co-ordinated in the way described. But by leaning forward or on one side, and still more by putting out one foot while keeping the other stationary, I can reach additional objects, and make them yield me combined sets of feelings very much like the preceding ones. They are not quite like however; for each of them contains certain additional elements—the feelings accompanying the partial change of place. These feelings form an intercalated set of links by which the visual cluster and its concomitants are brought into a relation of co-existence with the tactual cluster and its concomitants. They become important elements in the cluster in proportion as the objects are difficult to reach without moving from the spot. But while they thus make somewhat indefinite the division between the relatively-simple and direct co-ordinations that have been described, and the relatively-complex and indirect co-ordinations to be next dealt with, they do not obliterate the broad contrast.

For now mark that beyond the objects I see within easy reach, and beyond the objects I see and can reach by leaning, or by putting out one foot, there are immensely-more numerous objects which I see but cannot reach without locomotion, brief or prolonged. While I stand where I do, the picture on the opposite wall cannot by any actions of mine be made to yield me tactual impressions: I put out my hands towards it, I bend my body in the same direction, I put one foot forward, all to no purpose. That I may touch it, I must take several steps, with their successive groups of muscular feelings in my legs and tactual feelings on the soles of my feet. Thus beyond the small space surrounding my body, there lie successive concentric portions of space containing objects which after being seen cannot be tactually explored until there have been executed certain movements either of walking or running or leaping, of climbing up or getting down—the concomitant feelings varying with the direction and with the distance. Manifestly, we have here an order of co-ordinations vastly larger in number than the first; and manifestly, within this order itself the co-ordinations become increasingly numerous and increasingly complex as the remoteness increases. More than this is true. Co-ordinations of this higher order differ from those of the lower order, not only by containing clusters of locomotive feelings which join the visual cluster with the tactual cluster: they differ in another all-essential character. For the original visual cluster *never is* brought into direct relation with the tactual cluster. That which is brought into direct relation with the tactual cluster is another visual cluster (always larger and always somewhat different in form) which has been substituted for the original cluster. To exemplify by symbols—if the set of feelings yielded to the eye and eye-muscles by a distant object be called A, then before the sets of feelings which the object will give to the fingers and arm-muscles can be had, A must go through a series of transformations A, A, A, A. The original visual cluster comes to be co-ordinated with the corresponding tactual cluster, only through a series of visual clusters which have a certain dependence on the series of locomotive clusters. Nor is this all. Like changes have occurred in the visual clusters produced by other objects within sight. These, too, have undergone enlargements, and alterations in the relations of their parts; and many of them have disappeared laterally from the field of view. So that establishment of one of these adjustments in which our eyes guide our limbs to manipulate things at a distance, implies co-ordinations not only of great complexity in comparison with those required for manipulating things close to us, but co-ordinations that are made more complex by the introduction of new elements combined in new ways.

§ 240. In asking how such higher co-ordinations are evolved out of lower ones, and how the structure of the nervous system becomes progressively complicated in such way as to achieve them, the cardinal fact to be remembered is that such higher co-ordinations are effected by *intercalations* of new clustered states between the original clustered states. Hence it is to be expected that in the nervous apparatus which achieves them, there must be intercalated plexuses of fibres and cells.

If in Fig. 15, we suppose *a* to be the place to which are brought through many fibres the clustered sensations yielded

Fig. 15



by an object seen within reach; if at *b* are the roots of fibres which co-operate when this object is grasped; and if between *a* and *b* lie the co-ordinating plexuses through which the compound sensory excitements lead to those compound motor excitements that cause prehension of the object, not when in one position only but when in the various positions it may occupy within reach; what will happen if some steps have to be taken before the visual impression is followed by prehension? The *recipio-motor* and *dirigo-motor* changes gone through during these acts of locomotion, imply sundry compound co-ordinations with their correlative plexuses. Whatever sets of plexuses are successively so excited that the fibres at *b* are eventually acted on in the way required to cause prehension, it must happen that these sets of plexuses will become a network of lines of least resistance. For as shown in § 237, muscular co-ordinations that fail have, other things equal, less tendency to be repeated when the same conditions recur than those that succeed; because those that succeed open lines of discharge that draw off large amounts of molecular motion. Between *a* and *b*, therefore, there will arise intercalated sets of plexuses which co-ordinate the successive locomotions and accompanying visual impressions gone through between the receipt of the original visual impression and the performance of the eventual prehension. These sets of plexuses must be very numerous. Supposing the object to be one step out of reach, it may occupy multitudinous positions, high or low, to the right or left; and the required co-ordinating plexus for each position, while it has much in common with those for adjacent positions, must have something different. But the space between *a* and *b* is already occupied by the plexuses which effect the direct co-ordinations. Hence the intercalated plexuses which effect these indirect co-ordinations, must be super-posed, as at *d;* and the co-ordinating discharges must take roundabout courses, as shown by the arrow.

Each such position being reached through visual and muscular co-ordinations which are, within narrow limits, the same for all members of a species, it follows that there will eventually arise in the species an organized set of connexions such that the visual impression produced by an object in that position and the muscular actions by which it may be grasped are definitely correlated. Little by little the positions composing wider and wider spheres of space may come to be thus mentally possessed; while there is a concurrent enlargement of the superior co-ordinating centre, by the intercalation of new co-ordinating plexuses at its periphery, as shown at *e*, *f*, *g*.

§ 241. One further elaboration remains. To render the exposition of this doubly-compound co-ordination less difficult to follow, I have thus far treated of it as though the relational elements involved were all of one class. But in reality there are two distinct classes of them, requiring distinct centres of co-ordination.

So long as the visual, muscular, and tactual impressions to be co-ordinated, refer exclusively to objects within reach, the relations of succession and the relations of co-existence are not definitely parted. It is true that when anything within this range has yielded its visual impressions, a certain series of muscular states has to be gone through before it yields its tactual impressions. But when these have been gone through, the visual impressions as at first received and the tactual impressions as subsequently gained, co-exist—I can continuously gaze at the thing and continuously grasp it. Moreover, it is to be noted that in all these cases the order of sequence in the consciousness of visual impressions and tactual impressions may be inverted—I can feel the thing first and see it after. But when we pass from these compound co-ordinations to the doubly-compound co-ordinations, the elements of succession become of no less importance than the elements of co-existence. The serial states gone through can no longer be dropped out of the group, and the sequence from visual to tactual cannot by any possibility be inverted. That is to say, the time-relations and the space-relations have become distinctly differentiated. This needs some further explanation. When I walk towards an object, successive clusters of muscular and tactual feelings are implied by the steps I make; there is an accompanying series of gradually-enlarging and otherwise-changing visual impressions from the object as I approach it; and serial changes, more numerous and complicated, are produced through my eyes by adjacent objects. All of these successions, if I keep my eyes open, and certain of them even if I close my eyes, must be gone through before the tactual impressions to be received from the object can be had. The visual impression which the object made on me before I moved towards it, can be brought into relation with this tactual impression only through certain serial states; and these not only form an indispensable chain by which the initial and terminal clusters of states are bound together, but they form a chain no one link of which can be taken out of its place—their order is fixed. Here then we have co-ordinations in Space and co-ordinations in Time uniting to achieve the entire co-ordination. Before a step is taken towards the object, the impressions made by it and all things around, stand in a plexus of relations of co-existence. Each step implies muscular and tactual sequences accompanied by numerous visual sequences; and the step ends by bringing about a modified plexus of co-existences. The two orders of relations are therefore correlatives, and serve to interpret one another. Without some means of registering the series of motions to be gone through in reaching the object, there could be no consciousness of its distance. Without consciousness of its distance the muscular feelings gone through could have no meanings in thought as the equivalents of certain spaces traversed.

But the differentiation of these two great orders of relations implies a differentiation of co-ordinating centres. What form this differentiation takes among inferior types of animals we need not here inquire. In the highest or vertebrate type, however, there are, as before pointed out, reasons for concluding that the cerebellum is the organ of doubly-compound co-ordination in Space while the cerebrum is the organ of doubly-compound co-ordination in Time. To the reasons before assigned for this conclusion I may here add some others. One is that these two supreme nervous centres are pedunculated masses growing out of the enlarged and differentiated extremity of the spinal cord, much as we might expect the centres of doubly-compound co-ordination to grow out of the centre of compound co-ordination. Another is that they preserve a general relationship in their development. From fishes upwards their evolution goes on, if not with equal steps, still in something like proportion. This is a trait to be expected; since the greater developments of senses and limbs which they accompany imply simultaneously-increased experiences of time-relations and space-relations. As we approach the highest vertebrate types the cerebrum develops at a greater rate than the cerebellum—a fact also to be anticipated. For in the simpler vertebrate animals the only time-relations appreciable are those disclosed along with space-relations by acts of locomotion. But in the more complex vertebrate animals, whose organized experiences of time-relations thus acquired yield measures of duration of some length, other orders of sequences become cognizable; and the nervous centre in which time-relations are co-ordinated thus acquires functions peculiar to itself. The compositions of these two great centres harmonize with the hypothesis. The process described in § 240 implies that a centre of doubly-compound co-ordination will be evolved by the intercalation of plexuses and the superposing of plexuses in successive strata—each new stratum added at the periphery of the mass serving to re-coordinate the co-ordinating plexuses below it. The layers of cells and fibres which the cerebellum and cerebrum contain, seem fit to constitute appliances of this kind. Yet again, the minute structure of the cerebellum is more regular than that of the cerebrum; and this answers to the comparative homogeneity of its function. Even from the beginning some such difference must tend to arise. The experiences disclosing relations of co-existence in space have a great sameness; and though those which bring a consciousness of increasingly-remote space are increasingly complex, yet the complexity increases after a simple systematic manner. If all movements were always made at the same velocities, then the time-relations disclosed in locomotion would be as uniform as the space-relations; and the nervous centre which co-ordinated the actions to them might be equally homogeneous in structure. But since the movements are very variable in speed, not only as made on different occasions, and as made by different muscles, but even as made by the same muscle during different parts of its contraction, there is a cause of heterogeneity in the co-ordination of time-relations which we may expect to be expressed by some heterogeneity in the nervous plexuses effecting them. Still more must such heterogeneity be looked for when we pass to time-relations of a higher order. The sequences that become appreciable when intelligence becomes high, are sequences of very numerous orders, of very various lengths, and between terms of very various complexities; as instance the contrast between the succession of sounds in speech and the succession of the seasons. After contemplating the multitudes of these time-relations occurring between all kinds of things, differing enormously in their durations, and having countless degrees of heterogeneity, we shall not be surprised to find that the organ of doubly-compound co-ordination in time presents marked unlikenesses of a minute structure in its different regions.

§ 242. I need not attempt further to complicate this synthesis by including those actions in which tastes, odours, sounds, &c., play a part. Already in seeking to build up a general conception of the process of nervous evolution in its higher stages I have elaborated the argument quite far enough—perhaps too far.

Let me, indeed, disclaim the endeavour, which some may suppose I have been making, to explain the process in full. My purpose has been rather to make the possibility of such a process conceivable; and I have taken specific cases and used concrete language because so only could I make myself understood. The actual genesis has been much more involved than that which I have described—so involved that a true delineation, even could it be made, would be scarcely comprehensible.

It may be well here to repeat the caution against attaching literal meanings to some of the terms used. The interpretations of such phrases as "nervous connexions" and "plexuses of fibres," must not be too strict. We are not warranted by observation in supposing that "connexions" and "plexuses" are quite definite; nor does the argument require us so to suppose them. That which the argument requires is a plexus of *channels* through which compound stimuli may be united and re-distributed into compound impulses; and these channels may be formed partly of distinct fibres and partly of unmarked lines of discharge through the imbedding protoplasm. Indeed it is manifest that in the nervous structures which carry on the higher mental actions the connexions must have all degrees of definiteness, and that the greater part of them must be very indefinite—the ultimate ramifications of the channels through which the discharges find their ways must be invisible.

CHAPTER VI.

FUNCTIONS AS RELATED TO THESE STRUCTURES.

§ 243. In tracing out the genesis of nervous structures, a good deal has been implied respecting the genesis of accompanying functions. Fully to understand the natures of these functions, however, it is needful to contemplate them by themselves in their ascending succession.

Throughout the foregoing argument, functions, when referred to, have been expressed in physiological language. It remains to translate this into psychological language. What have been considered as increasingly-complex nervous actions we have now to consider as increasingly-complex mental states.

§ 244. In reflex action of the earliest kind, a single stimulus at the periphery of an afferent nerve sends a wave of molecular change to a nerve-centre, whence, through ready-made channels, the wave instantly escapes in a more or less augmented form along an efferent nerve and excites some organ or organs—contractile organs being those to which we may here confine our attention. And such fully-established reflex action, not delayed a moment in its course, is unconscious.

A compound reflex action that is fully established, though implying the reception of peripheral stimuli by several afferent nerves, the passage of resulting waves through a ganglionic net-work, and the emission of discharges through motor nerves more or less numerous, is also unconscious—the passage through the central plexus not occupying the time which consciousness implies.

But compound reflex actions in which the co-operating stimuli produce the combined motor impulses only after a pause, caused by incompleteness in the permeability of the central plexus, may be presumed to have some accompanying consciousness—some feeling that occupies the interval between the receipt of the impressions and the escape of the discharges.

Each compound reflex action, accompanied at first by consciousness, but made by perpetual repetition automatic and unconscious, becomes a step towards reflex actions still more compound. These, during their stage of partial establishment, imply consciousness that is somewhat more complex and varied than the earlier consciousness which has been lost in automatic action.

Besides the consciousness accompanying those reflex actions which are but partially established, there is implied a much larger body of consciousness. For as already shown, the sense-organs that occasionally receive the special combinations of stimuli which cause automatically certain adjusted contractions of muscles, are sense-organs that perpetually receive stimuli not specially combined—stimuli which are therefore sending into the central plexuses, waves of disturbance that are not instantly draughted off to particular motor organs. These, dwelling in the nervous centres as long as the stimuli continue to be received, imply, as their psychical correlatives, what we call sensations, or something homologous with them.

The great mass of the sensations thus produced by external objects on a creature that has reached this stage of evolution, constitute an unorganized consciousness—a consciousness of which very few components have any specific order or definite meaning. Impressions received through the eyes of such a creature are mostly mere patches of colour, associated very feebly, if at all, with the tactual impressions yielded by the same objects. Only in the cases of those environing things to which the compound reflex actions or instincts are either adjusted or in course of adjustment, does this raw material of mind rise into nascent intelligence.

This nascent intelligence exists, however, not only where new compound reflex actions are being established, but also where an established compound reflex action is incipiently excited. Suppose such an animal as we have been considering, sees approaching some small creature of the kind on which it preys. Then, while this small creature is coming nearer, but before it has reached the point at which its visual image arouses the reflex action that effects its seizure, a series of visual images, increasing in size and definiteness, must be yielded by it; and it must yield an accompanying series of stimuli to the eye-muscles. Though the reflex action takes place only when the retinal and muscular impressions become combined in a certain way, yet during approach to the required combination the reflex action is tending to arise—there is a gradually-increasing excitement of the nervo-motor apparatus which will presently perform the reflex action. The effect does not stop here. Through the established connexions there is propagated a gradually-increasing excitement of the nervo-motor apparatus which catching the prey will bring into play—there are produced faint revivals of the tactual and gustatory states which capture of such prey has on past occasions yielded. Thus, then, results what we call *perception*; for we have here a cluster of real feelings caused by the presented object, joined with a cluster of ideal feelings, representing certain other real feelings which the object has before produced and can again produce.

Perceptions of this order are gradually extended to other surrounding things. The apparatus effecting the perceptions which are followed by reflex actions, is capable of effecting perceptions which are not followed by reflex actions. Clustered visual feelings yielded by inanimate bodies, are, like those yielded by animate bodies, apt to be joined in experience with clustered feelings yielded by them to the skin and muscles; and the two clusters so excited, though less frequently forming a sequence, eventually become correlated in a similar way. Thus the chaotic impressions received from environing objects, are slowly evolved into a slightly-organized consciousness of environing objects.

§ 245. Between a perception physiologically considered and a perception psychologically considered, the relation now becomes manifest. We see that a perception can have in a nerve-centre no definite localization, but only a diffused localization. No one excited fibre or cell produces consciousness of an external object: the consciousness of such external object implies excitement of a plexus of fibres and cells. And not only does this plexus of fibres and cells differ with every different object, but it differs with every different position of the same object. A clear understanding of this may be conveyed by an illustration.

A good piano has, including semi-tones, between eighty and ninety notes—say, for convenience of calculation, a hundred: to which last number, indeed, a pedal piano reaches nearly, if not quite. Such a piano, then, if its keys are struck singly, is capable of yielding but a hundred different tones. If its keys be struck two together, the different combinations that are possible amount to 4,950; if three together, to 161,700; if four together, to 3,921,225; if five together, to 75,287,520. These numbers, increasing thus with enormous rapidity as the complexity of the chords increases (until we reach chords of fifty notes, after which they begin to diminish), yield, when added up, a total requiring a row of thirty figures to express it—a million,

million, million, million, millions. Each combination is, considered as a set of sonorous vibrations, unlike every other; and though the majority of them are but inconspicuously different, yet there are millions of millions of them that differ in well-marked ways. So that out of this comparatively-simple structure a practically-unlimited number of functional effects is producible. If now, instead of the keys of the piano, we suppose a cluster of such sensitive bodies as those which form the retina; if instead of the appliances which convey to the strings the impacts given to the keys, we take the fibres that carry to the optic centres the impressions made on these retinal elements; and if instead of strings made to vibrate we put ganglion corpuscles excited by the impulses they receive; we shall see that a perception may be compared to a musical chord. As by striking a certain set of keys there is brought out a particular combination of tones, simple or complex, concordant or discordant; so when a special object seen strikes by its image a special cluster of retinal elements, and through them sends waves to the fibres and cells of a corresponding central plexus, there results the special aggregate of feelings constituting perception of the object. Without further detail the reader will see how it thus becomes possible for a limited number of fibres and cells to become the seat of a relatively-unlimited number of perceptions.

While it thus in a general way illustrates perception under one of its aspects, the action of a piano fails wholly to illustrate it under another of its aspects; as the motions of a dead mechanism must necessarily fail to represent in full the functions of a living one. For, as above pointed out, a perception is formed only when a cluster of real feelings excites a correlated cluster of ideal feelings. If our piano were so constituted that after any two chords had been repeatedly sounded in succession, there resulted some structural change, such that when the first of these chords was again evoked by a performer's hands a faint echo of the second chord followed without aid from the performer's hands, the parallel would be nearer. We should then have something analogous to what happens when a nervous plexus excited by certain properties of an object, diffuses its excitement to another plexus that has, on previous occasions, been excited by other properties of the object. And here, indeed, while we are giving the rein to imagination, let us take a wider licence—let us suppose that several chords struck in succession, thus aroused faint repetitions of the many following chords forming the rest of the music to which they belonged. We shall then be helped to conceive more nearly how the elements of perceptions become linked together. And on contemplating the infinity of musical effects obtained by combining different compound chords in ever-varying successions, we shall get some idea of the infinity of perceptions that arise by the organizing of clusters of co-existing feelings in endlessly changing sequences.

§ 246. We may now pass from perceptions to *ideas*, properly so-called. Though every true perception along with its presentative feelings necessarily contains certain representative feelings, these do not at first become what we usually understand by ideas. They have not the detachableness which distinguishes ideas that are fully developed. They can be called into existence only by the sense-impressions with which they are directly connected in experience; and they can continue to exist only so long as these continue to exist. To return to our illustration—a creature so constructed as to be capable of nothing beyond the compound co-ordinations just described, resembles a piano that is silent until touched by the hands of the performer. Its nervous system is played upon by external objects, the clustered properties of which draw out answering chords of feelings, followed by faintly-reverberating chords of further feelings; but it is otherwise passive—it cannot evolve a consciousness that is independent of the immediate environment.

How does such independent consciousness become possible? When do ideas, rightly so-called, arise? They arise when compound co-ordination passes into doubly-compound co-ordination. They grow distinct in proportion as the correspondence extends in Space and Time. They acquire a separateness from direct impressions as fast as there increase those series of clustered sensations which unite the visual sensations received from objects out of reach with the tactual sensations afterwards yielded by such objects. They are the necessary concomitants of that process by which, through intercalated psychical states, there is established a mediate relation between psychical states that cannot be brought into immediate relation. And they have for their seats those intercalated plexuses which co-ordinate the co-ordinating plexuses previously existing. That is to say, ideas form a larger and larger portion of consciousness as fast as there develop those two great pedunculated nerve-centres which distinguish the superior animals; ideas become more multitudinous and more separable from direct sense-impressions as these centres increase in size and structure; and eventually, when these centres are highly evolved, ideas admit of combination into trains of thought that are quite independent of present external perceptions.

By carrying a step further the illustration used in the last section, we may now get a better notion of the parts which the cerebrum and cerebellum play in mental processes. For just as, by the actions of appropriate mechanisms joined to them, musical instruments of certain kinds are made to yield musical combinations without the hands of the performer; so, through the workings of these great appended nerve-centres, there are called out from the centres below them, trains of consciousness independent of, or additional to, those aroused by impressions on the senses. To make the parallelism understood, let me describe, at some length, one order of these mechanical appliances. Every one has watched the revolving barrel of a musical box, as its pins strike, in successive combinations, the vibrating metal tongues; and every one sees that the set of pins, arranged in a special way, represents, in a sense, the harmonized melody produced. By moving the barrel a small distance longitudinally, another set of pins, clustered in another way, is brought into position, ready, when the barrel revolves, to bring out another set of chords and cadences; and so on. The mechanical arrangement in this case, restricts very closely the number of musical combinations which the barrel can contain, or rather, which its clustered pins can represent. But it is easy to conceive an arrangement permitting indefinite multiplication of such combinations. If we suppose the sheet of metal forming the surface of the barrel to be cut longitudinally, and unrolled into a flat surface without disturbing the inserted pins, it is clear that if this flat surface were moved down vertically in front of the metal tongues, between rollers which kept it properly in place, its pins might be made to strike the metal tongues just as they now do. And it will at once be seen that any number of such flat plates, all having differently-clustered pins representing different harmonized melodies, might be made to pass through the rollers. A further complication, needed to complete the analogy, will now be readily understood. In the musical box, the chords and sequences admit of being produced only by these pre-adjusted appliances. But there exists a species of mechanical piano capable of being played upon in the ordinary way, and also of having drawn from it an unlimited number of pieces of music after a method akin to that last described. Looking much like an ordinary cottage-piano, this instrument has, protruding through its top, a second set of small keys that stand vertically in a closely-packed row. When certain adjacent rollers fitly adjusted are turned round, a flat board placed beneath them is drawn along horizontally, so that the specially-arranged metal pins on its under surface, by striking this row of keys, produce the successive chords and phrases of an air. And such boards, each incapable of emitting a note, but having in the arrangements of its parts a latent power of eliciting from the piano a special piece of music, may be multiplied without end.* If, now, we compare one of these tune-boards to the nervous plexus of fibres and cells which effects a doubly-compound co-ordination; and if we consider the cerebrum and cerebellum as like vast magazines of such tune-boards, duly classified and adjusted for being brought into instant action; our comparison will fail in several ways to convey an adequate conception. Instead of appliances each having its quite distinct and quite independent combination, we require appliances that are not quite distinct or independent, but have larger or smaller parts of their combinations in common. Further, we must imagine kindred appliances of a higher order, which do not themselves elicit the harmonized melodies, but which re-combine in various ways, simultaneous and successive, the appliances that do this—represent, as it were, whole concerts of them specially arranged; and so on in still higher gradations. We require also to suppose that the potential musical pieces, and combinations of such pieces, thus constituted, admit of being brought into action not only apart from, but also along with, the original keys; so that when some bars have been performed by the pianist, this attached apparatus, thereby set going, gives out in faint tones few or many of the bars previously connected with those sounded. Above all,

* A *piano-mécanique* of this kind was shown in the French Department of the Great Exhibition of 1851 by A. Debain. I find that Cramer is now his English agent for the sale of them.

we have to assume a process unapproachable by any apparatus of human manufacture—a process through which repetition of the actions serves to establish the connexions. But though the illustration fall short in so many ways, it helps us to imagine the kind of relation which the highest nervous structures bear to lower ones. We are enabled by it to understand better how thinking goes on along with, or apart from, the perception of external things. It removes the difficulty of conceiving that the centre of compound co-ordination, to which all centripetal nerves bring their impressions and from which issue through centrifugal nerves motor impulses, continues to the last to be the sentient centre. We see that while this centre is the seat of the sensations aroused by external stimuli, and the place in which these are brought into relation with other sensations similarly aroused; it is also the place in which such feelings and relations are feebly re-aroused, in the same combinations and in other combinations, by discharges through the fibres of the overlying cerebral masses. We see, in short, that the *medulla oblongata* (with its subordinate structures) while played upon through the senses by external objects, is simultaneously played upon by the cerebrum and cerebellum: so producing the thought-consciousness that accompanies sense-consciousness.

§ 247. One further question to be asked is—What, from this point of view, is an *emotion?* If, recalling the conclusion reached in §§ 213–216, we join with it the above inferences, we shall, I think, get a satisfactory answer.

As said, and tacitly implied, in various places, the co-ordinating plexus by which any cluster of sensations is made to excite the appropriate muscular actions, must in great measure coincide with other plexuses by which allied clusters of sensations are made to excite allied actions. In proportion as the external things responded to have much in common, and the required motions have much in common, the plexuses that effect the adjustments will have much in common. Not only of the plexuses which effect compound co-ordinations must this be true: it must be true also of those which effect doubly-compound co-ordinations. But the more involved the co-ordinations become the less definite will be these agreements; since, along with the progressive compounding of impressions and motions, there necessarily goes multiplication of differences in details. Let us exemplify.

The plexuses which co-ordinate the visual impressions yielded by an apple on the table, with the motor acts required to grasp it and with the ideas of tactual and gustatory sensations it will yield, are nearly the same as certain plexuses that have before worked together. Those which establish the consciousness of the apple's relative position in space, answer almost exactly to those which have established the consciousness of that relative position in space when occupied by other objects, alike in the experience of the individual and in the experience of antecedent individuals; and those which establish the consciousness of the apple's smoothness, hardness, odour, and taste, as related to its form and colour, are the same within narrow limits as those which have, in previous experiences of the individual, done the like. Along with this agreement of the plexuses the consciousness is definite. Take now, in contrast, the nervous structures excited, and the correlative mental state produced, by an animal that threatens attack—say a fierce dog. It growls, it puts back its ears, it shows its teeth, it advances in an active way. But the motions, the gestures, and the sounds it makes, while they considerably resemble those made by other dogs on other occasions, do not coincide with them by any means closely. Much less do they agree with those made by another animal in a similar mood—say an angry bull; though in the rapidity of the approach, in the energy of the movements, in the loudness of the sounds, there is a general similarity. And they differ still more from the demonstrations made by a furious man; though these, too, have in common with them the threatening advance, the violent actions, and the loud harsh tones. It follows, then, that the co-ordinating plexuses brought into play by perception of an approaching enemy on successive occasions, never coincide in detail, even when the enemy is of the same kind; and their non-coincidence is great in proportion as the enemies are of kinds differing in their appearances and modes of action. Let us next consider what happens if the threatened attack becomes an actual attack. There is pain, there is struggling, there are cries, perhaps of anger, perhaps of agony—all implying violent excitements of particular plexuses. But the plexuses excited do not coincide with those before excited by such attacks. The pains do not come from the same injured parts; the struggles are unlike in their combinations; the sounds emitted differ in pitch, or intensity, or order—usually in all of these. So that though the plexuses have much in common they have a great deal not in common. Mark further that these agreements and disagreements obtain not in the experiences of each individual only, but in the experiences of successive individuals. Generation after generation the approach of enemies has excited certain nervous structures in ways much alike in some few general characters, but unlike in multitudinous special characters; and there has followed the excitement of other structures that have similarly agreed in part and disagreed in part. What has resulted? Each plexus has been inherited in the form of a well-organized set of connexions in the midst of many less definite connexions, obscured by multitudinous feeble connexions; and the inherited central connexions of the plexus first excited, are definitely connected with the inherited central connexions of the similarly-constructed plexus that is habitually excited after it. The accompanying subjective results are these. The consciousness of an approaching body making sounds and motions of a certain kind, is followed by a consciousness of painful states, sensory and motor, having no definite localizations. The immediate perception, with the crowd of ideas resulting from preceding similar perceptions, arouses not only ideas of particular pains that have before followed such perceptions in the life of the individual; but through the inherited organization it arouses an indefinable sense of ill—a cloud of dim feelings of suffering that cannot be reduced to form because they have not been personally experienced—the emotion of *fear*. And with the primitive form of fear, thus physically organized and psychically constituted, there are afterwards integrated the higher and more involved forms of fear; all of which have for their central element, ideal feelings of pain or discomfort that are unlocalizable and therefore vague.

Respecting emotions it has only to be added that they, like ideas, result from the co-ordinating actions of the cerebrum and cerebellum upon the *medulla oblongata* and structures it presides over. As the plexuses in these highest nervous centres, by exciting in distinct ways special sets of plexuses in the inferior centres, call up special sets of ideal feelings and relations; so, by simultaneously exciting in diffused ways the general sets of plexuses to which these special sets belong, they call up in vague forms the accompanying general sets of ideal feelings and relations—the emotional background appropriate to the definite conception. In the language of our illustration, we may say that the superior nervous centres in playing upon the inferior ones, brings out not only specific chords and cadences of feelings, but, in so doing, arouse reverberating echoes of all kindred chords and cadences that have been struck during an immeasurable past—producing a great volume of indefinite tones harmonizing with the definite tones.*

* Let me in passing remark that these views of the respective functions of the nervous centres, make intelligible various physiological and patholo-

§ 248. A few remarks are here called for respecting the tenets of the phrenologists. It scarcely needs saying that the conception above elaborated, implying the constant co-operation of all the leading nervous centres in every thought and emotion, is quite at variance with their theory, as presented by themselves. But it may be necessary to point out that I do not hence infer the *absolute* untruth of their theory.

That the contemptuous antagonism they have met with from both psychologists and physiologists is in great measure deserved, must be admitted. They have put forth their body of doctrines as in itself a complete system of Psychology—naturally repelling by this absurdity all students of mental science. At best, Phrenology can be but an appendix to Psychology proper; and one of comparative unimportance, scientifically considered. That those who have carefully investigated the structure and functions of the nervous system, should have long ago turned their backs on Phrenology, is also not to be wondered at; seeing how extremely loose the phrenologists are in their methods of observation and reasoning, and how obstinately they ignore the adverse evidence furnished by experiment.

Nevertheless, it seems to me that most physiologists have not sufficiently recognized the general truth of which Phre-

gical phenomena. We see how it is possible for the cerebrum and cerebellum to be greatly injured, and indeed wholly shorn away, without destroying the power to perform the simpler acts of perception and co-ordination; just as it is possible for the mechanical piano, after the removal of all its tune-boards, to continue responsive to the hands of the musician. Again, the *medulla* being the seat of all feelings, whether aroused from without or from within, it naturally happens that its undue excitement, in whatever way caused, produces through the vagus nerve like effects on the viscera —it naturally happens that sensations intensely painful or pleasurable, and emotions intensely painful or pleasurable, alike cause fainting, and that fainting may be caused even by intense intellectual action. Similarly, it becomes comprehensible why the *medulla* is so generally the seat of chronic nervous disorders; whether the excess from which they arise be sensational, emotional, or intellectual.

nology is an adumbration. Whoever calmly considers the question, cannot long resist the conviction that different parts of the cerebrum must, *in some way or other*, subserve different kinds of mental action. Localization of function is the law of all organization whatever; and it would be marvellous were there here an exception. If it be admitted that the cerebral hemispheres are the seats of the higher psychical activities; if it be admitted that among these higher psychical activities there are distinctions of kind, which, though not definite, are yet practically recognizable; it cannot be denied, without going in direct opposition to established physiological principles, that these more or less distinct kinds of psychical activity must be carried on in more or less distinct parts of the cerebral hemispheres. To question this is to ignore the truths of nerve-physiology as well as those of physiology in general. It is proved, experimentally, that every bundle of nerve-fibres and every ganglion has a special duty; and that each part of every such bundle and every such ganglion has a duty still more special. Can it be, then, that in the great hemispherical ganglia alone, this specialization of duty does not hold? That there are no conspicuous divisions here is true; but it is also true in other cases where there are undeniable differences of function—instance the spinal cord, or one of the great nerve-bundles. Just as there are aggregated together in a sciatic nerve an immense number of fibres, each of which has a particular office referring to some one part of the leg, but all of which have for their joint duty the management of the leg as a whole; so, in any one region of the cerebrum, each fibre may be concluded to have some particular office which, in common with the particular offices of many neighbouring fibres, is merged in some general office fulfilled by that region of the cerebrum. Any other hypothesis seems to me, on the face of it, untenable. Either there is some arrangement, some organization, in the cerebrum, or there is none. If there is no organization, the cerebrum is a chaotic mass of fibres, incapable of performing any orderly action. If there is some organization, it must consist in that same "physiological division of labour" in which all organization consists; and there is no division of labour, physiological or other, but what involves the concentration of special kinds of activity in special places.

But to coincide with the doctrine of the phrenologists in its most abstract shape, is by no means to coincide with their concrete embodiments of it. Indeed, the crudity of their philosophy is such as may well make men who to some extent agree with them, refrain from avowal of their agreement: more especially when they are met by so great an unwillingness to listen to any criticisms on the detailed scheme rashly promulgated as finally settled.

Among fundamental objections to their views, the first to be set down is that they are unwarranted in assuming *precise* demarkations of the faculties. The only localization which the necessities of the case imply, is one of a comparatively vague kind—one which does not suppose specific limits, but an insensible shading-off. And this is just the conclusion to which all the preceding investigations point. For as we have seen that every mental faculty, rightly understood, is an internal plexus of nervous connexions corresponding to some plexus of relations among external phenomena that are habitually experienced; and as the different plexuses of external relations, in proportion as they become complicated, become less definite in their distinctions, so that when we reach those extremely involved ones to which the higher faculties respond there arises a great overlapping and entanglement of different plexuses; it follows that the answering internal plexuses must be fused together—it must be as impossible to demarkate the internal nervous aggregations, as it is to demarkate the aggregations of external things and actions.

Moreover, I believe the phrenologists to be wrong in assuming that there is something specific and unalterable in the natures of the various faculties. Responding, as faculties do, to particular assemblages of phenomena habitually surrounding any race of organisms, they are only so far fixed and specific as these are fixed and specific. A permanent alteration in one of these assemblages, would in time establish a modified feeling adapted to the modified assemblage. A habit—say of sitting in a particular place in a particular room, ending in being uncomfortable elsewhere—is nothing but an incipient emotion answering to that group of outer relations; and if all the successors of the person having this habit were constantly placed in the same relations, the incipient emotion would become an established emotion. So little specific are the faculties that no one of them is quite of the same quality in different persons. Each mental power is variable to as great an extent as each feature is variable.

Yet further, the current impression of phrenologists seems to be that the different parts of the cerebrum in which they locate different faculties, are of themselves competent to produce the manifestations implied by the names they bear. The portion of brain marked "acquisitiveness," is supposed to be alone concerned in producing the desire of possession. But it is a corollary from foregoing arguments that this desire includes a number of minor desires elsewhere located. As every more complex aggregation of psychical states, is evolved by the union of simpler aggregations previously established—results from the co-ordination and consolidation of these; it follows that that which becomes more especially the seat of this more complex aggregation, or higher feeling, is simply the *centre of co-ordination* by which all the simpler aggregations are brought into relation. Hence, that particular portion of the cerebrum in which a particular faculty is said to be located, must be regarded as an agency by which the various actions going on in many other parts of the cerebrum are combined in a particular way. The brain, active throughout, evolves under the co-ordinating plexus that is for the time dominant, an aggregate of feelings that is various in quality according to the proportions and arrangements of its components; just as out of the same orchestra, with its many instruments going from moment to moment, are drawn combinations of sounds now grave, now gay, now martial, now pathetic, according to the way in which the actions of its parts are co-ordinated by the composer's score.

Saying nothing of many minor objections to the phrenological doctrine, we conclude that however defensible may be the hypothesis of a localization of faculties, when presented under an abstract form, it is quite indefensible under the form given to it by phrenologists.*

* In the first edition of *The Principles of Psychology*, the substance of this section was contained in Part IV.—forming the conclusion to the chapter on "The Feelings."

CHAPTER VII.

PSYCHICAL LAWS AS THUS INTERPRETED.

§ 249. The final stage of the synthetic argument has at length been reached. The task now before us is to compare the deductions made in foregoing chapters from a physical principle, with the inductively-established laws of mental action, and to see if the two correspond.

It was pointed out in § 222 that the *à priori* law of intelligence would be fulfilled, and the growth of intelligence would be explained, if it could be shown "that when a wave of molecular transformation passes through a nervous structure, there is wrought in the structure a modification such that, other things equal, a subsequent like wave passes through this structure with greater facility than its predecessor." It was thereafter inferred from established mechanical principles, that a structural change of this kind will occur. And we have since occupied ourselves in tracing up nervous evolution as an accumulated result of such changes. All that remains is to observe whether the facts of daily experience are similarly interpretable—whether the hypothesis is further verified by the agreement of its corollaries with the generalizations of psychologists and with popularly-recognized truths.

§ 250. The congruity between the established laws of association and the several implications of the physical principle laid down, is conspicuous.

Experience continually shows us that, other things equal, the connexion formed between two feelings or ideas that occur together or in succession, is strong when they are vivid and feeble when they are faint. This truth is deducible from the hypothesis. In proportion to the strength of the discharge passing through a line of unsymmetrically placed molecules, will be the amount of force expended in bringing them towards symmetrical arrangement: so enabling them to convey the next discharge with less resistance. Whence it follows that the more vivid the connected feelings the more readily will recurrence of the one cause recurrence of the other—the closer will be the association between them.

It is a proposition equally familiar, that repetition of the relation between two states of consciousness, presentative or representative, strengthens their union. The more frequently transition from the first to the second occurs, the more coherent they become—the more easily does the antecedent arouse the consequent. This, too, is a corollary from our hypothesis. For the implication of the argument set forth in § 224 is, that of the molecular motion discharged along a line of isomerically-changing molecules unsymmetrically arranged, part is passed on by each molecule to the next, while part is absorbed in bringing it towards symmetrical relations with its neighbours. Hence of a subsequent like discharge, more will be passed on and less will be absorbed in this re-arrangement: there will be a diminished resistance to the excitement of the one nervous state by the other; and the correlative feelings will become more coherent.

A further fact finds here, too, its explanation. In the process of connecting mental states, it is observable that the earlier repetitions of the relation between them have greater effects than the later repetitions. For some time, recurrences of a sequence go on appreciably increasing the readiness with which the antecedent excites the consequent; but the increase gradually becomes less and less appreciable. The saying that practice makes perfect is but approximately true. The proficiency gained by practice (as we see plainly in games of skill which furnish definite measures of proficiency) augments at first rapidly, then less rapidly, and at length scarcely at all: each individual reaches a limit beyond which repetitions of the nervous changes and concomitant successions of feelings bring no sensible improvement. The physical cause is this. When a wave of molecular motion passes through a line of molecules that are greatly out of symmetrical arrangement, much of it is absorbed in turning them toward symmetrical arrangement. As they approach nearer and nearer to symmetrical arrangement, more and more of the wave passes on—less and less is thus absorbed. But to say that each molecule offers a diminishing resistance to the transfer of the wave, is to say that there is a diminution of the force which tends to bring it into polar relations with its neighbours. And since the molecule has inertia and is also restrained by the actions of surrounding molecules, the force available for altering its position bears a continually-decreasing ratio to the forces that maintain its position; until at length the effect of this re-adjusting force becomes insensible.

§ 251. The laws of more complex mental changes are similarly interpretable. I refer to the phenomena of habit, considered under those involved forms in which the emotions play a leading part.

It is a familiar fact that a course of action, or a mode of life, originally repugnant, usually, in course of time, gets less repugnant—eventually becoming indifferent or even agreeable. Physiologically considered, a disagreeable course of action is one in which compound feelings have to issue in compound actions, through complex nervous structures that offer considerable resistance. The result is that an extra quantity of feeling (commonly the fear of pain that may result from non-performance) has to be evoked before the actions can be excited. But since the complex discharges through these complex channels render them gradually more permeable, it results that the quantity of disagreeable representation of pain required to excite the actions, decreases; and at length the permeability of these channels may become such that the spontaneous flow of ordinary feelings suffices—nay, these channels may become needful for the due discharge of ordinary feelings; which otherwise discharge themselves in the purposeless activity we call restlessness.

Where the inherited organization already affords channels for the easy discharge of special feelings in special actions —that is, where there pre-exists an emotion prompting a particular kind of conduct, we see that often-repeated passage of such emotion into such conduct renders less and less resistible its tendency thus to pass. The more frequently the impulse is yielded to, the more difficult becomes restraint of it; until at length the act it excites follows the feeblest solicitation of the impulse. Truths of this class, continually illustrated among the lower impulses and illustrated as clearly, though less frequently, among the higher impulses, are corollaries from the same general principle.

§ 252. From this general principle, too, may be derived an explanation of certain leading traits of developed intelligence, as distinguished from intelligence which is undeveloped.

We have seen how from the process of nervous evolution as physically caused, it follows that actions become less automatic as they become more complex. When but a single afferent nerve runs to a single ganglion, whence issues a solitary efferent nerve to a solitary muscle, there can be no discrimination and no variety of action. When the reflex action becomes compound, responding to more numerous combined outer stimuli by more numerous combined inner actions, the change is in itself towards discrimination and variety of action, and opens the way to further changes in the same direction. For, as indicated in §§ 235, 237, in proportion as reflex actions increase in complication, there arise more numerous hesitations, both of the kind that habitually precede each established reflex action, and of the kind that accompany the partially-formed reflex actions. Similarly, as we ascend to intelligences in which highly-involved impressions initiate highly-involved kinds of conduct, the automatic and instinctive adjustments bear a continually-decreasing ratio to the mass of adjustments—there is an increasing proportion of actions that take place with deliberation and consciousness, as well as an increase in the amount of deliberation and degree of consciousness. What is the implication of this law as applying to different grades of men? It is that those having well-developed nervous systems will display a relatively-marked premeditation—an habitual representation of more various possibilities of cause, and conduct, and consequence—a greater tendency to suspense of judgments and an easier modification of judgments that have been formed. Those having nervous systems less developed, with fewer and simpler sets of connexions among their plexuses, will show less of hesitation—will be prone to premature conclusions that are difficult to change. Unlikenesses of this kind appear when we contrast the larger brained races with the smaller brained races—when from the comparatively-judicial intellect of the civilized man we pass to the intellect of the uncivilized man, sudden in its inferences, incapable of balancing evidence, and adhering obstinately to first impressions. And we may observe a difference similar in kind but smaller in degree between the modes of thought of men and women; for women are the more quick to draw conclusions, and retain more pertinaciously the beliefs once formed.

Of kindred meaning is the difference between the cultured and the uncultured of the same race and of the same sex. The education of the individual (using the word education in its proper sense) is but a carrying further of that process by which intelligence in general has been evolved. It consists in extending and making better the correspondence of inner relations to outer relations—that is, in organizing the combinations of ideas into agreement with the combinations of phenomena. And its physical concomitant must be the formation in the individual of more multitudinous and more involved connexions of plexuses. The brain of the uncultivated man as compared to that of the cultivated man, must be one in which the routes taken by nervous discharges are less numerous, less involved, less varied in the resistances they offer—one, therefore, in which the number of ideas that can follow a given antecedent is smaller, and the degrees of strength with which they can present themselves are fewer—one, therefore, in which the possibilities of thought are more limited, and the balancing between alternative conclusions less easy. This is the reason that ignorant people generalize hastily, and adhere obstinately to the erroneous conclusions based on their scanty experiences; while the highly-instructed man is able to keep his judgment undecided—waits for more evidence, contemplates other possible inferences than the one he is inclined to draw, and is ready to abandon or qualify his conviction when he discovers facts at variance with it.

Without going further into detail, it will be obvious that these, and other traits of progressing intelligence, harmonize with the principle that lines of nervous communication are formed by the passage of waves of molecular motion, and become the more permeable the more frequently such waves are repeated.

§ 253. Mental evolution in its higher stages shows us a further peculiarity which has the same general nature and admits of the same general interpretation. I refer to that brought out by comparing the emotional characters of inferior and superior minds.

We have seen that beginning with simple feelings, rising to clusters of feelings, afterwards to clusters of these clusters, and so on to aggregates more massive and more heterogeneous, the nervous structures which are their seats advance in complication by the super-posing of new plexuses whereby pre-existing plexuses have their actions co-ordinated. The implication is that the earlier and simpler feelings, being the more directly intermediate between special combinations of external stimuli and special combinations of adapted actions, are the more independent of one another and the more liable to act separately; while as fast as there are evolved those later feelings into which the simpler ones enter as components, there is a decreased tendency for the simpler ones to act separately. In other words, the development of the highest plexuses is the development of appliances by which simpler plexuses of different kinds are simultaneously excited, and the different modes of action which they prompt, simultaneously made nascent. It results, then, that along with advancing evolution of the feelings there will go a diminution of fitfulness and uncertainty of conduct. An emotional nature not well developed will be relatively impulsive—the liability will be for each passion to display itself quickly and strongly, without check from the rest, and to exhaust itself very soon. While, along with high emotional development there will be little liability to sudden outbursts of feeling—the simultaneous rise of one or more counter-feelings proper to the circumstances, will in most cases retard or qualify the manifestations; but the conduct eventually decided on, prompted by a greater number of feelings severally less excited, will be more persistent. Here, as before, the contrast between the higher and the lower races of men furnishes an illustration; and here, too, as before, a further but less marked illustration is furnished by the contrast between men and women.

Indeed, under this, as under other aspects, mental evolution, both intellectual and emotional, may be measured by the degree of remoteness from primitive reflex action. The formation of sudden, irreversible conclusions on the slenderest evidence, is less distant from reflex action than is the formation of deliberate and modifiable conclusions after much evidence has been collected. And, similarly, the quick passage of simple emotions into the particular kinds of conduct they prompt, is less distant from reflex action than is the comparatively-hesitating passage of compound emotions into kinds of conduct determined by the joint instigation of their components.

CHAPTER VIII.

EVIDENCE FROM NORMAL VARIATIONS.

§ 254. Thus far the evolution of nervous structures, and of their functions, has been considered without reference to the varying physiological conditions that affect the process from moment to moment, as well as from generation to generation. We have spoken as though the physical actions by which nervous channels are opened and made more permeable, equally with those by which the discharges along established channels produce their respective effects, are actions always alike in kind and degree if the stimuli and the structures are alike in kind and degree. But this is not the case. Here we must take note of several circumstances, general and local, which modify the influence of the same outer agent on the same inner part; and observe the correspondence between the variations of physical effect and the accompanying variations of psychical effect.

The better to follow in thought the production of these variations, let us carry further a comparison before made. When describing how discharges of molecular motion go along lines of least resistance, and by recurring render them lines of less resistance, it was pointed out that in this respect there is an analogy between the flow of molecular motion and the flow of a liquid; for a stream, in proportion as it is strong and continued, cuts for itself a large and definite channel (§ 224). That the transfer of molecular motion may be properly thus paralleled, we see in the case of those forms of molecular motion known as heat and electricity; the conduction of which through solid bodies, is compared to a flow that takes place more easily through some substances than through others, and which, in bodies having polarized molecules, passes with less resistance in some directions than in others.* Reverting, then, to the common hypothesis of a nervous "fluid" which moves in nerve-"currents"—admitting that though the molecular motion which works nervous effects is not a fluid, and its transfer not a current, they may be conveniently dealt with as though they were; let us consider what variations of special results will arise from incidental variations in the genesis and escape of the nervous fluid. Let us consider the nervous system as an immensely involved set of channels, some wide and allowing an easy flow, some narrow and little permeable—some communicating with one another by large openings and others by openings through which nothing passes except under high pressure; but all of them more or less permeable and more or less connected. Let us suppose the aggregate of channels so constituted, to have multitudinous places through which its contents escape and multitudinous places through which there come gushes that increase its contents; and that these places of subtraction and addition are opened in various localities, in various numbers, and in various degrees—sometimes the subtractions being in excess and sometimes the additions. Let us hence infer a considerable variability of pressure in the fluid filling these ramifying channels—some excessive outflow having now greatly reduced its pressure, and the large inflows having now raised its pressure above the usual height. And lastly, let us draw the necessary corollary that at one time its ebbing streams pass only along the fully open and the more permeable channels; while at a time of high tide its streams find their

* See Prof. Tyndall's *Heat as a Mode of Motion*, Chapter VII.

ways into less permeable channels, and, aided by local disturbances, escape even through the least permeable channels.

Thus symbolizing the physical actions to which the nervous system as a whole is exposed, let us ask how its functions will be affected by changes of physiological conditions; and how the accompanying subjective states will be modified.

§ 255. Take first the general variations which are seen on contrasting certain mental traits of youth and age.

While waste and repair are rapid, the ramifying set of channels forming the nervous system, receives such a large and perpetual influx at multitudinous points, that it remains well filled notwithstanding the large efflux continuously going on at multitudinous points. The ingoing waves of molecular motion caused by peripheral impressions, liberate from moment to moment, in the sensory centres, larger waves, or, as we may here call them, quick gushes of the "nervous fluid;" and from the massive plexuses of the higher centres, aroused by combinations of disturbances thus arising, there are added to the contents of the nervous system still more powerful and continuous gushes. Considering first the physiological results, we see that the channels of the automatic nervous system are filled to overflowing. The heart pulsates powerfully; the alimentary canal works vigorously; the lungs are well inflated; and every glandular organ receives that continuous discharge which keeps up the peculiar molecular changes carried on in it. Meanwhile the voluntary muscles, receiving their share of this abundant efflux, are all in states of partial tension, so producing attitudes characteristic of vigour; and they are severally ready to contract with great force, and to keep up their contractions for long periods. Among accompanying psychical results, we see that the feelings of both orders are vivid: the sensations are distinct and the emotions lively. We see also—and this it is which more especially concerns us here—that the establishment of relations between feelings is easy, and that the relations when established are relatively permanent. Along whatever lines of nervous communication are opened, discharges pass that are strong because the pressure is great; whence results a great amount of molecular re-arrangement along each line taken by a discharge. A subsequent like discharge passes with comparative facility; making the antecedent state easily produce the consequent state—the terms of the relation are rendered coherent—the memory of it is good.

The converse connexion of phenomena in advanced life, brings out more clearly, by contrast, the law we are contemplating. In common with the body at large, the nervous system is supplied with poorer blood circulated more slowly; and hence when wasted it is less rapidly repaired. Its channels, therefore, receive from moment to moment feebler gushes of nervous fluid; the general pressure is diminished; and all the various overflowing gushes become less. The physiological results are that the actions of the viscera go on more slowly. Digestion if not positively difficult is a sensible tax; and the propulsion of blood to the surface is no longer active enough to contend with any great loss of heat. Throughout the muscular system, too, the failing nervous discharge is seen; alike in the chronic relaxation of attitude and in the quick following of fatigue upon exertion. Psychically, this state is one in which the feelings aroused are less vivid and the relations formed between them less coherent. For reading a strong light is required, taste and smell become less keen, hearing grows dull, and there is apathy in presence of circumstances which yield strong pleasurable emotions to the young. At the same time the comparative want of cohesion between impressions is shown in the inability to recollect the names of persons, the times of occurrences, &c. And if we trace out the successive stages of failing memory, we see that they follow the order inferable from the hypothesis. Earliest among the related impressions which no longer so cohere that one recalls another, are those made by daily trivialities—those represented in the nervous system by lines through which feeble discharges have but once passed. Interesting statements that are read, and passing events of considerable importance, presently cease to be recallable; though like statements and events which date back to early life are still recallable: the reason being that the channels of nervous communication long ago made by the strong gushes answering to the vivid feelings of youth, remain more permeable than those lately made by the feebler gushes answering to the fainter feelings of age. Passing over many gradations, we come to incoherences of thought in which the place now inhabited is confounded with places inhabited long ago, and the business of middle life is referred to as though transacted yesterday—incoherences implying that comparatively permeable channels are now so far deserted that the discharges along them do not arouse the elements of these familiar ideas in their proper relations. And eventually we reach the extreme state, similarly explicable, in which even members of the family, who have been companions through life, cease to be recognized.

§ 256. Let us consider next certain general psychical variations that accompany differences of bodily constitution. Some of these, of the same natures as the foregoing, we will glance at before passing to some of another nature.

In consequence of specialities of inheritance, specialities of education, and specialities of mode of life, high mental manifestations of certain kinds may go along with weakness of body. But classing such cases as abnormal deviations from that constitutional balance which is needful for survival through future generations; and limiting our attention to cases where no monstrosity has been produced by undue forcing of the individual or his ancestors; we shall, I think, trace a connexion between abounding physical vigour and power of thinking and feeling, as well as between sluggishness of constitution and comparative inertness, intellectual and emotional. On the one hand we have a type of man overflowing with muscular energy that gives superiority in sports, games, and feats of strength; who is keenly alive to all orders of gratifications, sensational and emotional; who acquires knowledge easily, and retains it tenaciously; and who, after leaving the academic life throughout which he was marked by these united traits, gains distinction partly because of his mental activity (not necessarily of a high order), and partly because of the strength of constitution which enables him to bear intense and prolonged application. On the other hand we have a type of man whose bodily functions are slow; who from boyhood upwards cares little for active exercises; who even in youth is indifferent to pleasures which others enjoy greatly; who all along finds learning laborious; and who, in after life, lapses into apathetic idleness.

These contrasts between men whose nervous systems work under high pressure and under low pressure respectively, I draw less for the purpose of showing their analogy to the contrasts between the young and the old, than for the purpose of drawing attention to accompanying contrasts of another kind. We have seen that when the pressure throughout the nervous system is high, so that any disturbance which facilitates escape along certain channels is followed by a strong gush along those channels, even though they are not very permeable; there is an easy revival of old connexions of ideas and a formation of new connexions that are very coherent. But there is much more than this. Interwoven as the higher nervous plexuses are in such intricate ways, in correspondence with the intricate interweaving of phenomena, it necessarily happens that a wave of nervous fluid let into one of them, though it escapes most largely along certain most permeable channels, escapes in part along other channels that are less permeable. The stronger the wave the greater the number of these supplementary discharges; and the further do all the discharges, larger and smaller, make themselves felt—rushing out into more multitudinous and remote ramifications of the plexuses they enter. Answering to this physical result the psychical result is the production of ideas that are more numerous, and more distinct, and more discursive. The area of consciousness simultaneously widens and brightens as the pressure of the nervous fluid increases; so that while its near and central elements become clearer, elements more distant from the centre come into view. Between the two types of constitution above described, we see such mental differences as are hence to be inferred. The man whose nervous system works under high pressure shows us an abundance of ideas. He has always something to say; and instantly finds words fit for the occasion. All the proximate bearings of a situation or an event quickly occur to him; and out of the several courses which almost simultaneously suggest themselves, he takes the appropriate one. He thus shows what we call "presence of mind;" and habitually trusting with success to the fertility of his resources, he has courage in facing difficulties. In the man whose nervous system works at low pressure, thoughts come slowly in single file instead of rapidly in a column formed of many almost abreast. The various possible causes and consequences of each act dawn upon him gradually one by one, and some of them not at all; so that the occasion has passed before he has had time to adjust himself to it. Finding that he is consequently unable to cope with men who have "their wits about them," he leaves the crowded thoroughfares of life and takes to its quiet byeways.

§ 257. That general physical causes entail such general psychical differences, we see not only on contrasting the minds of the young and old as well as those of the constitutionally vivacious and the constitutionally sluggish, but also on contrasting the exalted and depressed constitutional states of the same individual.

Most persons have had experience of a general prostration during which pleasures are accepted apathetically, while thinking is a fatigue and the effort to recollect unfamiliar things repugnant; and along with this diminished cohesion of ideas there is a diminished number of them—instead of coming in a continuous crowd they come as a train of stragglers. Conversely, there is an exceptional invigoration, often traceable to some favourable combination of conditions, physical and social (as an excursion along with intimate friends) in which the mental manifestations are unusually vivid and abundant. Every thought is clearly and quickly seized; apt expressions come to the mouth without hesitation; illustrations are ready on the instant; long-forgotten anecdotes recur; and out of the flood of ideas, now so broad and swift, there are readily formed those complex combinations of likeness and difference which constitute wit, even by those who ordinarily are not witty.

Clearly these opposite deviations from the mean state, are, like the others, interpretable as caused by relatively low pressure, and relatively high pressure, throughout the nervous system.

§ 258. One other variation of constitutional state, occurring daily, presents us with a series of similar effects similarly produced.

The diminution of nervous efflux which, reaching a certain point, shows itself in an increasing quietude, lapsing into sleep, is accompanied by a descending series of psychical activities conforming to the general principle set forth. When drowsiness begins, there is first a failure of the feebler and more complex connexions of ideas, as well as a decreased quantity of ideas. Thought leaves its remoter and less-beaten tracks, and confines its excursions to the more familiar tracks—common-place remarks and allusions take the place of wit and speculation. Gradually becoming limited to a still narrower range, consciousness is by-and-bye made up of little else than those almost automatic interpretations of the impressions received from things around which constitute recognitions of them. And at length when the circulation has fallen to the requisite degree, and low tide of the nervous efflux has been reached, even the place and the persons are no longer known.

The dreams that occur during the ensuing sleep present traits of like meaning. For sleep-consciousness, while differing from waking consciousness mainly in being independent of, and uncorrected by, impressions received through the senses, differs also as the consciousness of the old does from that of the young, or that of the inert from that of the vivacious. Its elements are less coherent and less abundant. An ordinary dream is so faint that it is not recallable unless thought of just after waking; and then only a few of its closing scenes are recallable. Even these are not coherent over any considerable space; but through some accidental associations each new act or occurrence leads off into quite another series of acts and occurrences—there is a perpetual wandering away from what was just before thought or intended. Meanwhile, the narrowing of the area of consciousness is shown in the absence of those multitudinous collateral thoughts which the successive scenes are fitted to arouse, and in the consequent acceptance of these scenes without any sense of their absurdity. To dream of flying and not to suspect any illusion, implies that thought is limited to a narrow train of simple ideas; and that there are not aroused any remembrances of those antagonistic experiences and of those general conceptions framed on them, which are implied by scepticism and disbelief.

A verification meets us when we compare the dreams accompanying quiet circulation of the blood, with the dreams accompanying excited circulation—either through the system as a whole or through the brain only. For under conditions implying a higher rate of molecular change, and consequently of nervous discharge, than is usual during sleep, the dreams become both more vivid and more rational. Many acts are performed in succession with a view to some desired end; and the earlier members of the series do not wholly disappear from consciousness as the later arise. At the same time the things done, the means used, the difficulties overcome, are less incongruous with waking experience; because of the greater excursiveness of thought, and the consequent accompaniment of criticism on the main current of ideas.

§ 259. Another class of facts offer a kindred problem which admits of a kindred solution. I refer to the psychical variations that accompany variations not in the state of the organism as a whole but in the states of its different parts.

Given a nervous system in any constitutional condition, what will happen to the rest if one portion of it is greatly excited? Supposing large demands to be made on the general supply of nervous fluid by a powerful discharge in one direction, what will be the effects on discharges in other directions? The question is not by any means simple; for ordinarily a nervous action is accompanied by an invigorated pulse and a raised respiration, whence it results that being better supplied with materials, the nervous system generates more nervous fluid. Up to a certain point, therefore, the efflux in the performance of some one kind of function, has the effect of increasing instead of diminishing the general efflux. This is especially the case with those modes of nervous expenditure which bring with them increased excitements of the sensations and emotions. Nevertheless there is reason to suspect that some effects such as the hypothesis implies are produced.

When muscular effort is suddenly pushed to excess, say by running a long way at full speed or by climbing a mountain till forced to desist by want of breath, the power of thinking is appreciably diminished. Though it remains easy to unite ideas in simple combinations, it becomes difficult to unite them in complex combinations—a metaphysical question demands a greater mental effort than can be made. The emotions undergo a like enfeeblement—a temporary apathy ensues. That is to say, an excessive abstraction of nervous fluid diminishes so much the general pressure throughout the nervous system, that no discharges take place along the less permeable channels. It is true that the aeration of the blood falls in arrear, and that diminished genesis of nervous fluid thus becomes a part-cause of these effects; but we shall find evidence that it is only a part-cause. For the alleged connexion of phenomena is quite clearly shown on passing to those nervous discharges which have not increased excitements of feelings as their concomitants. When the muscles and glands of the alimentary canal are at work, the heart and lungs have their actions raised; and the evolution of nervous energy is thereby favoured. But their activity brings no such increased evolution of nervous energy as does that of the locomotive organs; since their activity neither yields direct sensations, nor incidentally entails more vivid and varied perceptions and ideas, with the feelings immediate and remote which they imply. Consequently, the abstraction of nervous fluid by the stomach when food has been put into it, is an almost uncompensated deduction from the general supply of nervous fluid. In youth the mental effect is not much felt; but in middle life and after, we see that the digestion of a heavy meal (at least in the absence of social excitements) entails such a diminution of pressure throughout the nervous system, that only the simple and coherent relations of ideas are formed with facility. Processes of thought which imply discharges through involved sets of channels that are not very permeable, are performed with difficulty. There is a disinclination to mental work as well as to bodily work; and not uncommonly, the overflow so far fails that even the simpler relations of ideas becoming faint and confused, there presently follows the unconsciousness of sleep.

§ 260. More special antagonisms, akin to these in their natures and effects, may be traced. A very strong emotion makes such a draught on the supply of nervous fluid as to incapacitate the intellect throughout much of its higher sphere. Conceptions that come in the lines of production and discharge of the emotion, may be formed with facility and vividness (though in some persons even these fall into confusion); but conceptions unconnected with the occasion, especially of kinds that are abstract or involved, become for the time impossible. There seems some reason to think that, conversely, great expenditure of energy in intense intellectual action is accompanied by a temporary diminution of emotional sensibility. It may be suspected, too, that long-continued intellectual absorption, of a kind which has little or no emotional excitement for its accompaniment, leads to a permanent enfeeblement of the emotions. Indeed, there is an antagonism of different faculties that appears to necessitate this—competing with one another as they do for supplies of energy and materials from the same general stock.

But the most interesting and instructive solution belonging to this group, is that afforded of the aberrations which emotions produce among intellectual processes. When we remember that the plexuses co-operating in any involved mental act, are made up of multitudinous channels of various degrees of permeability, we shall see that the mental act can be properly performed only when the discharges through the co-operating plexuses take place under the normal pressure. As before shown, the least permeable plexuses are the first to become functionally inactive as the pressure diminishes; and here it is to be observed that for the same reason, the least permeable parts of each plexus will as the pressure diminishes have their discharges appreciably enfeebled before the more permeable parts. But right mental adjustments, implying accurate nervous co-ordinations, depend on the maintenance of due *proportions* among the strengths of the discharges; and anything that alters these proportions interferes with the adjustments. Necessarily, then, a strong emotion disturbs the intellectual balance. Both derangements of simple perceptions and derangements of complex judgments show us this. Among derangements of perceptions, I may refer in passing to those which great fear produces—the misinterpretation of visual impressions being in this state of mind very marked. But examples that are better, because the effects are numerically measurable, occur among those who play games of skill. If when about to make a stroke at billiards any emotion has been raised, by the presence of spectators or otherwise, failure is very apt to result; and this though the heart's action and the muscular tone are not appreciably affected. The cause is clear. Success presupposes great exactness in the ratios among the many combined contractions, and in the adaptation of them all to the many combined impressions; the ratios among which have also to be exactly appreciated. But when a great draught of nervous fluid to the parts of the nervous system occupied in an emotion, has diminished the pressure under which these sensory and motor discharges are made through the co-operating plexuses, the ratios among the actions of their parts are so far changed that the co-ordination becomes imperfect. That among those higher intellectual actions we class as judgments, a like disturbance leads to a like derangement, is obvious.

Take a case. To decide which of several results will most likely follow some step, say in a negociation, implies representations of them as caused by complex motives and circumstances. These several results rise in consciousness with different degrees of vividness and pertinacity; and to believe that one of them will occur, is to feel that this one persists in consciousness more decidedly than the others—the greater persistence being determined by some preponderance of kindred experiences. But due proportion among the tendencies of these several representations to arise and continue, depends on the maintenance of the normal pressure or nervous fluid. This is interfered with both locally and generally by strong emotions. In the first place, the particular emotions excited in reference to the question at issue, perturb the judgment by increasing the discharge along those lines of representation that further their own excitement. In the second place, these particular emotions, or any other emotions, perturb the judgment by affecting the general supply of nervous fluid. Under the high tide which extreme elation implies, the nervous discharges pass easily along the less permeable channels, and the feebler representations are raised more nearly to a level with stronger ones, so that discrimination becomes less easy; whence it happens that improbable results of a desired kind are thought probable. While under a state of depressed spirits, judgment fails because the proportions among the nervous discharges are interfered with in an opposite way.

§ 261. Fully to explain these last derangements of judgment, however, we must take into account one further class of variations among the mental activities. In entering on this class, I find the opportunity of redeeming a promise made in § 128; where, after propounding an hypothesis respecting the natures of pleasures and pains, it was hinted that some verification would be furnished at a later stage of the argument. We saw reason to think "that while Pleasures and Pains are partly constituted of those local and conspicuous elements of feeling directly aroused by special stimuli, they are largely, if not mainly, composed of secondary elements of feeling aroused indirectly by diffused stimulation of the nervous system." Here we have to consider what further reasons for thinking this are now apparent; and what further solutions they introduce us to.

That every special pleasure or pain, peripheral or central, does produce a diffused effect is clear. I do not mean simply that this is a corollary from the foregoing argument: I mean that it is shown experimentally. Beyond the familiar fact that each strong sensation or emotion affects the action of the heart, we have the fact that the accompanying gush of nervous fluid, spreading along all the vaso-motor nerves, changes the state of the arteries throughout the whole body. Much more then does it spread through those more directly-related parts of the nervous system which are seats of conscious actions. What remains here to inquire, then, is how far the diffusion is specialized according to the nature of the feeling.

In tracing out the genesis of emotions, we have seen that the plexuses which co-ordinate certain clustered impressions received from without, with the combined actions appropriate to them, are necessarily entangled with kindred plexuses that perform kindred co-ordinations. We have inferred that when a particular plexus is excited, it immediately excites the mass of kindred plexuses with which it is organized—the result being that the feelings proper to this mass of excited plexuses are aroused, and in their multitudinous but vague aggregate, constitute the accompanying emotion. But the process does not end here. This mass of plexuses thus excited has to discharge itself; and the question now to be asked is—what general directions will its discharge take, and what will be the general nature of the produced feelings? The answer is this. Any excited mass of plexuses will discharge itself into the masses of plexuses with which it has most in common, and these into others similarly related to them. Now the plexuses in which one kind of pleasurable emotion is seated, must have much in common with the plexuses in which some other kinds of pleasurable emotions are seated; seeing that the external plexuses of phenomena to which they refer have much in common, and frequently occur together. The smiles and tones expressing affection are approached by those expressing approbation. The natural language of approbation is a good deal like the natural language of benevolent feeling. The manner of one who acts kindly to us is similar to the manner which on many past occasions has preceded and accompanied the receipt of kindnesses, and arouses a dim consciousness of pleasures that are followed—perhaps of agreeable society, perhaps of beautiful scenery, perhaps of field sports, perhaps of all these. Evidently, then, the tendency is for any one pleasurable emotion to discharge itself in partially exciting pleasurable emotions of other kinds; so that, more or less remotely, all kinds of pleasures come to be ideally presented in a faint way. But since besides being faint they are so multitudinous and so various in quality, the resulting consciousness is wholly indefinite; and can be described only as a sense of satisfaction or of happiness. Similarly with pains. A particular form of bodily suffering produced by internal derangement, is linked by near resemblance with other forms of bodily suffering so produced; some of these by their localities and qualities are associated in consciousness with the pains caused by external cuts and bruises; some of these, again, are connected in experience with the impressions received from creatures about to inflict bodily injuries on us; and, of such impressions, some have much in common with those received from men who, if they do not threaten bodily injuries, are likely to do something that will be positively or negatively painful to us in its ultimate results. Hence a special pain, or rather the liberated nervous fluid which occurrence of it implies, discharging itself along lines of least resistance, partially awakens ideas of associated pains, and through these a vaguer consciousness of pains more distantly related, till by its ultimate diffusion there is generated an obscure feeling of discomfort or unhappiness. And hence results the peculiarity before pointed out (§ 128) that the total consciousness produced by a particular pleasure (or pain) is much more like the total consciousness produced by other particular pleasures (or pains) than is the initial feeling which arouses it like the initial feelings which arouse them.

By joining with this conception the inferences reached above, it becomes possible to account for a remaining psychical variation of a seemingly mysterious nature. How does it happen that a certain state of the circulation, or of the blood, or of both, causes in consciousness a predominance of painful ideas and a vague feeling of misery; while another state of the circulation, or of the blood, or of both, causes a predominance of pleasurable ideas, backed by a general sense of content or even of exhilaration—and this, too, in presence of the same circumstances? We find no answer in any recognized laws of psychical action; nor does any answer seem deducible from established principles of nerve-physiology. We shall, however, find an answer in that synthesis of the two which we are here pursuing.

The diffusion of nervous discharges is ordinarily still wider that I have just described it to be—is indeed, as at first indicated, universal. When the initial feelings are of a pleasurable kind, the diffusion is *predominantly* in the direction of associated pleasurable feelings; and conversely when the initial feelings are of a painful kind. But the diffusion is never exclusively in either direction, because the initial feelings of either kind are not separable from accompanying initial feelings which, if not of the opposite kind, are still of a kind related to both—namely, the indifferent feelings. The sights and sounds, the sensations of touch and muscular tension, which form the mass of our definite consciousness from moment to moment, are connected in experience with both pleasures and pains; and, unless when combined in particular ways, they tend to arouse ideas of the one kind as much as ideas of the other. Ordinarily, therefore, that background of consciousness which constitutes our "state of mind," as distinguished from our passing sensations, perceptions, and ideas, is a neutral compound in which the aggregate of perpetually-nascent pleasurable feelings is fused with the aggregate of perpetually-nascent painful feelings. Equanimity may be compared to white light, which, though composed of numerous colours is colourless; while pleasurable and painful moods of mind may be compared to the modifications of light that result from increasing the proportions of some rays or decreasing the proportions of others. "But how," it will be asked, "does this interpretation help us to explain the genesis of mental depression and mental elation? Following out the simile, may it not be said that as, by intensifying combustion we increase the brilliancy of the light without altering its quality, so, by exalting nervous action we ought simply to increase the vividness of consciousness without altering its quality?" The reason for answering in the negative is this.

One of the laws of association is that the stronger the feelings connected in experience the more easily does the one subsequently recall the other; and the physical counterpart of this law we have found to be that the channel taken by any nervous discharge is made the more permeable in proportion as the discharge is augmented. Now pains in general are more intense than pleasures in general. Indeed, as was pointed out when treating of the two (§ 123), pains of the positive order result from the excesses of actions which in lower degrees are pleasurable. Other things being equal then (that is to say the comparison being made between pleasures and pains belonging to the same class and that have been similarly repeated in experience) the idea of a pain follows its antecedent into consciousness more readily than the idea of pleasure. On the other hand, pleasures, though less intense, are more numerous, and are more variously linked with other elements of mind. Setting out with the mass of indifferent feelings forming our ordinary perceptive consciousness, we may say that in the "state of mind" which is its background, there are nascent a small number of painful feelings that are strong, a larger number of pleasurable feelings that are less strong, and a much larger number of feelings that are but slightly pleasurable: their respective cohesions with the indifferent feelings becoming, for the reasons given, less strong as they become more numerous. This being understood, we have now only to ask how variations of pressure throughout the nervous system will operate, to reach the solution we seek. When this pressure is high, the less permeable lines of discharge, answering to the feebler associations among our pleasurable feelings, are filled by the escaping currents; and the aggregate of faintly-aroused ideas of pleasure grows in extent as well as in strength. As the pressure augments, this diffused consciousness of pleasure bears an increasing ratio to the diffused consciousness of pain—so producing in its ascending degrees a sense of satisfaction, of happiness, of joy for which no reason can be given. Contrariwise, a failing genesis of nervous fluid being followed by cessation of the efflux along the least permeable lines of discharge, and presently by its cessation along lines next to these in their small permeability, it inevitably happens that as the pressure goes on diminishing, the aggregate of faintly-aroused pleasurable feelings bears a decreasing ratio to the aggregate of faintly-aroused painful feelings. And when the pressure has fallen so low that currents pass only along very permeable lines, it results that the diffused consciousness, or vague background to our definite perceptions and ideas, comes to be composed mainly of the aggregate of faintly-aroused painful feelings—so producing gloom, and roundless fear, and despair.

CHAPTER IX.

EVIDENCE FROM ABNORMAL VARIATIONS.

§ 262. In cause and consequence, the case with which the last chapter closed introduces us to variations of the abnormal class. States of body and mind like that described, passing from the temporary into the permanent, become nervous disorders; presenting us with many psychical disturbances accompanying many physical disturbances.

We need not trace over again in these cases the relation between decreased genesis of nervous fluid and failure of mental power; for the relation is substantially the same as that which we have traced in the aged and in the constitutionally sluggish—there is a like failure of memory, a like narrowing of the area of consciousness as shown in diminished excursiveness of thought, and a like want of readiness in moments of emergency. But there is one other trait of nervous debility not hitherto pointed out, on which a few words may be said. I refer to the accompanying change of character, or modification of the emotional nature.

Even small ebbings of the nervous fluid, hardly to be called abnormal, produce slight modifications of this kind; as is observable in children. The highest co-ordinating plexuses being in them the least developed, children betray more quickly than adults any defective action of these plexuses; and they habitually do this when the general nervous pressure is below par. Sluggishness of the alimentary canal, implying partial failure of nutrition and decreased genesis of energy, is accompanied by fretfulness —by a display of the lower impulses uncontrolled by the higher. It is, however, in the chronically nervous, whose blood, deteriorated in quality and feebly propelled, fails to keep up a due activity of molecular change, that we see this connexion of phenomena most clearly. The irascibility of persons in this state is matter of common remark; and irascibility implies a relative inactivity of the superior feelings. It results when a sudden discharge, sent by a pain or annoyance through those plexuses which adjust the conduct to painful and annoying agencies, is unaccompanied by a discharge through those plexuses which adjust the conduct to many circumstances instead of a single circumstance. That deficient genesis of nervous fluid accounts for this loss of emotional balance, is a corollary from all that has gone before. The plexuses which co-ordinate the defensive and destructive activities, and in which are seated the accompanying feelings of antagonism and anger, are inherited from all antecedent races of creatures, and are therefore well organized—so well organized that the child in arms shows them in action. But the plexuses which, by connecting and co-ordinating a variety of inferior plexuses, adapt the behaviour to a variety of external requirements, have been but recently evolved; so that, besides being extensive and intricate, they are formed of much less permeable channels. Hence when the nervous system is not fully charged, these latest and highest structures are the first to fail. Instead of being instant to act, their actions, if appreciable at all, come too late to check the actions of the subordinate structures.*

* A verification seems worth naming. The sleeplessness often accompanying nervous debility, sometimes leads to the occasional use of morphia. A dose of this in excess of the need, causing undue nervous stimulation and waste, with excitement of the heart's action, entails a subsequent

§ 263. Among deviations towards a morbid state of an opposite kind, let us first note such as are apt to follow temporary and local excitations. These arise by insensible steps out of the ordinary deviations which accompany functional activity.

Each part of the brain, like the brain as a whole and like every other organ, requires, during the performance of its function, an augmented supply of blood. And of a cerebral plexus it doubtless holds as of a gland, that when called into action, the stimulus sent to the vaso-motor centre is reflected to the vessels of the part, in such way as to cause dilatation of them. During health, and when the plexus has not been too persistently exercised, this increased flow of blood through it ceases soon after the demand ceases. But extreme continuance of the activity even in those who have well-toned vascular systems, and very moderate continuance of it in those whose vascular systems are relaxed, leads to local congestion lasting for a considerable time; and there then occurs a more or less abnormal genesis of the correlative states of consciousness. Strong persons frequently illustrate this truth on landing after a sea-voyage of a day or two: they continue for hours to have illusive perceptions of rolling and pitching. And where, as in nervous people, the cerebral blood vessels easily lose their contractility, it commonly happens that a subject discussed, or even thought about with much intensity, monopolizes consciousness for a long time afterwards in spite of efforts to exclude it—often thus preventing sleep. Such congestions of cerebral plexuses have various degrees of duration—occasionally

further decrease in the genesis of nervous fluid; and the irritability and explosiveness then become greater than usual. There seems reason to think, too, that habitual opium-eaters, in whom this worst state has been made chronic, have these highest plexuses almost paralyzed; and are thus bereft of the feelings which should adjust their conduct in its remoter and more complex bearings. The lives of Coleridge and De Quincey furnish illustrations.

causing perversions in the currents of ideas persistent enough to attract the notice of those around. We find here a further verification of the hypothesis. Blood being needful for the performance of function, and the activity of function being, other things equal, proportionate to the supply of blood, it naturally happens that a continuance of the supply after the demand for function has ceased, causes undue readiness to resume function. When, among the data of psychology, we dealt with relations between blood and nervous action and feeling, we saw that an excess of blood at the periphery of the nervous system, as in an inflamed part of the skin, is accompanied by extreme sensitiveness: the molecular change then set up in the disturbed end of a nerve, is so great as to send an unduly powerful discharge to the point where feeling is aroused. If we transfer these conditions from periphery to centre, we at once see how this abnormal genesis of ideas results. As nervous discharges of all kinds are diffused and re-diffused until they affect the whole nervous system, we must regard every sensation, every thought, every emotion, as a propagator of disturbances, strong or weak, throughout the cerebral masses. The reverberations reaching plexuses in their ordinary states, draw from them but feeble reactions, and accompanying faint additions to the general body of consciousness. But when the reverberations reach plexuses made unduly sensitive by the presence of much blood, the reactions of their elements are unduly strong—the gushes of nervous fluid liberated, escaping along the habitual lines of discharge, arouse the correlative states of consciousness not faintly but vividly; and these, standing out from the background of consciousness, become the predominant thoughts and feelings.

If these physical processes are extended to the whole brain, there result multitudinous vivid ideas not of one kind but of many kinds. All the cerebral plexuses being rendered by excess of blood unduly sensitive, as well as initiators of unduly strong disturbances, consciousness becomes a torrent of intense thoughts and feelings; and if instead of congestion we have inflammation, order and proportion among the thoughts and feelings are quite lost—there is delirium.

§ 264. From temporary insanity, partial or general, of the kind caused by partial or general derangements of circulation, congestive or inflammatory, through the cerebral plexuses, we pass to the kind of permanent insanity that ensues when such derangements of circulation become permanent.

If nutrition of a cerebral plexus is much raised, or much altered in kind, by great excess of blood, the thoughts and feelings initiated are likely to be intensified to a degree that constitutes them illusions—we get monomania. Carrying out the analogy above indicated, we may say that as a touch on an inflamed surface of skin arouses as much feeling as a cut would ordinarily do; so a hyperæmic nervous plexus excited by some slight disturbance, reacts as violently as it would ordinarily do only after a very strong disturbance: the correlative psychical effect being the production of ideas that are unduly vivid—so vivid sometimes as to be scarcely, if at all, distinguishable from perceptions. Supposing this state lasts, structural changes occur in all the tissues implicated. Greatly exalting for a time the rate of molecular change, producing thickening and deposits, and leaving a degradation of structure inconsistent with the due discharge of function, the hyperæmia may, after making the correlative psychical states unduly vivid, end in enfeebling them—so entailing a changed form of mental affection.

If a chronic vascular derangement, or derangement of nutrition otherwise caused, extends to many or all of the cerebral plexuses, general insanity would seem fairly inferable. Should it be said that a deviation from the normal rate of tissue-metamorphosis throughout the cerebrum at large, either by increase or decrease, would seem only to necessitate a corresponding exaltation or depression of all the mental powers, and not a derangement of them, I reply as before (§ 260) that derangement of them is implied by any disturbance of the *proportions* among the intensities of states of consciousness, and that such disturbance is caused by anything that modifies them all indiscriminately. If the strengths of the nervous discharges are so raised that those passing along the less permeable channels set up molecular changes, and arouse correlative feelings, almost or quite as strong as the sensations aroused by peripheral stimuli, the gradations that normally exist among states of consciousness in respect of their degrees of vividness and degrees of cohesion, are either destroyed or seriously altered—judgment being perverted to a proportionate extent. And a perversion of judgment will likewise result if, from an opposite physical cause, some of the states of consciousness become too faint or disappear.

It is needful to add that though thus far chronic vascular derangements, and derangements of local nutrition entailed by them, have been named as causes of insanity, the implication that they are the only causes is by no means intended. Effete matters may, if they accumulate in the blood, produce molecular disturbances in the nervous centres through which they are continually carried; and molecular disturbances so set up will have for their concomitants disorders of the mental states. Or instead of a normal product of decomposition that has not been duly excreted, some introduced virus, or some morbid matter arising from constitutional disease, may, by thus acting as an irritant, perturb the currents of thoughts and feelings. That an impure blood is thus a possible, and indeed a probable, cause of insanity, we find good reason for believing.

§ 265. For we bring on a species of temporary insanity by putting certain poisons into the blood. Substances which, like opium and hashish, exalt the rate of molecular change in the nervous centres, so intensify the feelings and ideas as to cause illusions.

I need not follow out in detail the parallelism between the effects of increased pressure of nervous fluid produced by these drugs and increased pressure otherwise produced. Here, as before, there is such exaltation of ideal feelings as brings them near to real feelings in distinctness; such strengthening of the relations among them as causes failing memories to arise with clearness; such facility in the formation of remote and complex connexions of thoughts as constitutes a transfigured imagination; and such widening of consciousness as changes its quiet flow into a flood.

One thing only will I draw attention to—the verification yielded of a foregoing hypothesis respecting the genesis of "states of mind." As a corollary from the laws of association translated into terms of nervous action, we concluded that when the pressure of nervous fluid is low, the diffused discharges will be so distributed that the faintly revived feelings of pain will preponderate; that when the nervous pressure is up to par, the aggregate of feelings indistinctly awakened, pleasurable and painful, will form a neutral compound; and that when the pressure is high, the pleasurable elements of consciousness, relatively as well as positively increased in their amount, will constitute a sense of happiness. Here it is to be observed that artificial happiness is produced by artificial increase of pressure. The delightful reveries of the opium-eater constitute the temptation which he finds it so difficult to resist. And similarly with Indian hemp: "It is real happiness which is produced by hashish," says M. Moreau.

§ 266. To complete the outline of the evidence furnished by abnormal variations, a few words must be added on the effects of anæsthetics. These change the nervous actions and, correspondingly, change the states of mind. Are the changes they work interpretable as agreeing with the foregoing general doctrine? In great measure, I think, if not wholly.

It is admitted as holding generally of these various agents —alcohol, ether, chloroform, nitrous oxide, &c.—that when their anæsthetic effects begin, the highest nervous actions are the first to be arrested; and that the artificial paralysis implicates in descending order the lower, or simpler, or better-established nervous actions. Incipient intoxication shows itself in a failure to form involved and abstract relation of ideas, while it remains possible to form simpler relations. In the anæsthesia produced for surgical purposes, we have less opportunity of observing that the like happens; but assuming that it does so, we find all the successive symptoms conformable in their order to the hypothesis. According to M. Flourens and Dr. Snow, as quoted and, on the whole, endorsed by Dr. Anstie, the æther-narcosis produces the loss of—"1. The local sensibility of extreme parts, and the control of certain muscles situated in those parts. 2. The intellectual powers. 3. The power of coordination of the locomotive organs generally. 4. The power of perceiving sensory impressions, even from parts little removed from the spinal centres. 5. The power of breathing. 6. The movements of vegetative life—*e.g.*, of the heart, intestines, &c." Here loss of the intellectual powers is placed after loss of sensibility "of extreme parts"; but this discrepancy is due to the fact that paralysis of the *higher* intellectual powers, necessarily inconspicuous under the circumstances, is not specifically named, even where observable; and that only when the perceptions become confused are the intellectual powers set down as lost. The experiments, both with ether and chloroform, show clearly that some incoherence of thought is the first noticeable effect.

Making this correction of the statement, we may say that anæsthetics stop first the discharges along the incipient lines of nervous communication; next the discharges along lines a little better formed; and so on, until finally they stop the discharges along the fully-established lines. Limiting ourselves for brevity to the two extremes, we see that on the one hand, incoherence among the more involved thoughts implies that those least permeable channels of nervous discharge that have been formed by the comparatively-few experiences of the individual, have become impermeable; while, on the other hand, when the functions of the visceral nervous system cease, the implication is that discharges no longer pass even through those most permeable channels which have been inherited, in a ready-organized form, from an ancestry that runs back not simply through numberless individuals, but through numberless species.

Though the effects of anæsthetics thus yield confirmation of the belief that lines of nervous communication become permeable in proportion as the discharges through them are strong and frequent, they present some apparent obstacles to it. How is the preliminary stage of excitement, and even mental exaltation, reconcilable with the argument? How are the differential effects of different anæsthetics to be explained? How does it happen that in some cases sensation is abolished while there continues some consciousness of things around? I believe there are answers to these questions; but this general exposition would be too much encumbered by including them in it.*

§ 267. I have reserved till the last what needs to be said in answer to objections which critical readers have probably made, now to one and now to another, of the several foregoing interpretations. This I have done with the intention of ultimately pointing out that the interpretations must be taken not separately but together. The many causes of variation at work, interfere with one another in multitudinous ways and degrees—each is influenced by all and all by each.

* See Appendix.

Due co-ordination of any set of nervous discharges, and production of the appropriate combination of mental states accompanying it, depends, primarily, on the existence of fitly-organized nervous plexuses in fitly-adjusted molecular states; and this pre-supposes that the approximately-adapted structures which the individual inherited, have had their adaptation completed by his own activities. It depends, secondarily, on the general supply of nervous fluid; and the physical processes and accompanying psychical states will vary according as the pressure of nervous fluid is high, or moderate, or low. And it depends, tertiarily, on the extent to which nervous fluid is being at the time drawn off by other discharges—to the viscera, to the muscles, or to other parts of the nervous system. Along with these general determining causes have to be taken into account many more special determining causes—the state of the blood as rich or poor, as well or ill ærated, as freed or not freed from this or that waste matter; the state of the blood as containing morbid products or foreign substances; the supply of blood to the plexuses concerned, which depends partly on habit, as involving frequent or infrequent action of them, and partly on the character of the blood vessels, as contractile or the reverse; and, lastly, the state of these plexuses as modified by chronic derangements of nutrition due to local inflammation and its *sequelæ*.

Remembering that all these co-operative causes have to be taken into account, we shall, I think, see little difficulty in reconciling the various anomalies with the general principle set forth.

CHAPTER X.

RESULTS.

§ 268. A not unsatisfactory fulfilment of the anticipation with which we set out has, I think, been reached. In the General Synthesis mental development, traced up from its beginnings, was represented as a correspondence between inner and outer actions, that extends in Space and in Time, while it increases in Speciality, in Generality, and in Complexity. The Special Synthesis carried further this interpretation of mental development, by showing how the advancing correspondence, when translated into the more familiar terms of Reflex Action, Instinct, Memory, Reason, Feeling, and Will, is comprehensible as a continuous process naturally caused. And in the Physical Synthesis just concluded, this continuous process naturally caused has been interpreted as a cumulative result of physical actions that conform to known physical principles.

Nerve being supposed to have the molecular structure and properties which, at the beginning of this work, we found such numerous reasons for assigning to it; we have inferred from established laws of motion, that the molecular change wrought in it by every discharge it conveys, leaves it in a state for conveying a subsequent like discharge with less resistance. This, being the universal law of nervous action, explains the universal law of intelligence. In the foregoing chapters we have compared the various corollaries of the one with the various implications of the other; and we have found that, from the simplest to the most complex cases, physical principle and psychical manifestation agree. Regarding as superposed, each on the preceding, the structural effects produced generation after generation and species after species, we have formed a general conception of the manner in which the most complex nervous systems have arisen out of the simplest. Simultaneously, we have been helped to understand more clearly the natures of the various modes of consciousness—perceptions, ideas, emotions, &c. And, by pursuing the reasoning to its remoter consequences, we have found that both normal and abnormal variations of mental processes, even up to the changes of mood accompanying bodily changes and the ecstatic feelings aroused by certain drugs, are rendered comprehensible.

The sufficiency of this general principle to account for the facts, can of course be alleged only on the assumption that changes wrought in nervous structures by nervous functions are inheritable. Tacitly throughout the divisions preceding it, and avowedly throughout this Physical Synthesis, it has been taken for granted that from generation to generation there descend alterations of structure; both of the kind called spontaneous, and of the kind arising from functional actions. Throughout the earlier stages of nervous evolution, a leading and perhaps most active cause, has been the survival of individuals in which indirect influences have produced favourable variations of nervous structure. But throughout its later stages, the most active cause has been the direct production by functional changes of corresponding changes of nervous structure, and the transmission of these to posterity. Considering how involved are the nervous systems of superior creatures, there apply here with especial force the reasons before given (*Principles of Biology* § 166) for concluding that natural selection is an inadequate cause of evolution where many co-operative parts have to be simultaneously modified; and that in such cases the inheritance of functionally-produced modifications becomes the leading agency—survival of the fittest serving as an aid.

But these processes of direct and indirect equilibration being postulated as acting on all organisms throughout all time, we see that joining with them the inferred effect of every nervous discharge upon every channel passed through, we get an adequate explanation of nervous evolution, and the concomitant evolution of Mind.

§ 269. "Thus, then, we are brought face to face with unmistakable materialism," will exclaim many a reader. "Thus, then, it is positively asserted that Mind is a growth, and that it grows after the same general method as does the meanest fungus or the most degraded worm. Thus, then, we must infer that the profoundest intuitions of the discoverer and the sublimest inspirations of the poet—the most abstract conceptions of the mathematician as well as the noblest emotions of self-sacrificing sympathy—are but properties of certain matters arranged in particular ways."

Notwithstanding the explanations that have been from time to time given, such will, I doubt not, be a frequent apostrophe. So favourite a mode of meeting the inferences drawn, is sure to be again employed; though, as shown already, it tells only against a doctrine that has been repudiated. The general relation between mental manifestations and material structures traced out in the foregoing chapters, has implications identical with, and no wider than, those which familiar experiences thrust upon us. That drowsiness impedes thinking, that wine excites or stupefies according to amount and circumstances, that great loss of blood produces temporary unconsciousness, and that the unconsciousness of death results if breathing be stopped for a few minutes; are facts admitted by every one, be his theory of things what it may. That you cannot get out of the undeveloped child, thoughts and feelings like those you get out of the developed man; that the idiot, with brain permanently arrested in its growth, remains permanently incapable of any but the simplest mental actions; are propositions not denied by the most intemperate reviler of physiological psychology. But one who recognizes such facts and propositions, is just as much chargeable with materialism as one who puts together facts and propositions like those which constitute the foregoing exposition. Whoever grants that from the rudimentary consciousness implied by the vacant stare of the infant, up to the quickly-apprehensive, far-seeing, and variously-feeling consciousness of the adult, the transition is through slow steps of mental progress that accompany slow steps of bodily progress, tacitly asserts the same relation of Mind and Matter which is asserted by one who traces out the evolution of the nervous system and the accompanying evolution of intelligence, from the lowest to the highest forms of life.

But, as said here and before, the supposed implication is not the true implication. Let me once more point out what the true implication is. By way of preparation, however, we will first observe how the above apostrophe might be met by those to whom it would be fitly addressed.

§ 270. "Your reproaches seem to me strangely inconsistent with your avowed beliefs and sentiments," might say the materialist to his opponent. "You profess the profoundest reverence for the Creative Power, from which you hold the Universe to have proceeded. Yet of the visible and tangible part of the Universe, you speak in a way that would be appropriate were its origin diabolical; and you taunt me because I recognize in that which you treat with so much scorn, powers no less marvellous than those manifested in the human mind.

"You see this piece of steel—cold, motionless, and, as you suppose, insensitive to all that goes on around. An artizan uses a portion of it for making the balance-wheel of a watch. Immediately it proves itself modifiable by changes of temperature which our dull senses fail to appreciate. Though by no direct measures can we detect an alteration in the length of its beat; yet, indirectly, by finding that it loses one beat in a hundred thousand, we get proof that an imperceptible increase in the molecular agitation propagated to it by surrounding things, has augmented its diameter and expanded all its parts in the same ratio. Take another bit of this same apparently inert substance; shape it appropriately; bring it under the influence of an adjacent magnet; and throughout its mass there is wrought, in some incomprehensible way, an invisible change which enables it to do —what? 'To point north and south,' you say. Yes; but to do far more than this. Its perturbations will now show to an instructed eye, the rise and progress of a cyclone in the Sun.

"And what is the constitution of this seemingly-simple matter, which thus tells of things near and remote that remain otherwise unknown? In the minutest visible fragment of it there are millions of units severally oscillating with unimaginable speed; and physicists show us that the amplitudes of their oscillations vary from moment to moment, according as the temperatures of surrounding objects vary. Nay, much more than this is now inferable. Each unit is not simple but compound—not a single thing but a system of things. Spectrum-analysis has made it manifest that every molecule of this so-called elementary substance is a cluster of minor molecules differing in their weights and rhythms. Such being the complexity of matters we lately thought simple, judge what is the complexity of matters we know as compounds. In each molecule of an oxide or an acid, the chemist sees one of these systems united with one, two, three, or more systems of another kind that are similarly involved. Ascending to orders of compounds successively more heterogeneous, he finds himself obliged to recognize molecular complexities unrepresentable in thought; until, on reaching organic matter, he comes to molecules each of which (taking into account the composite nature of its so-called elements) contains literally more atoms than the visible heavens contains stars—atoms combined, system within system, in such ways that each atom, each system, each compound system, each doubly-compound system, has its motion in relation to the rest, and is capable of perturbing the rest and of being perturbed by them.

"This activity and this sensitiveness, which the investigator marvels at the more the deeper his discoveries reach, is possessed in common by ponderable matter and by the seemingly-imponderable matter pervading space. That the ether, so extreme in tenuity that we can scarcely represent it to ourselves as having materiality, is nevertheless composed of units which move in conformity to mechanical laws, is now a common-place of science. Hypothetically endowing these units with momenta, and assuming that in each undulation their courses are determined by composition of forces, mathematicians long ago found themselves able not only to interpret known properties of the light constituted by ethereal undulations, but to assert that it had unobserved properties; which were thereupon proved by observation to exist. Far greater community than this has been disclosed between the ponderable and the imponderable: the activities of either are unceasingly modified by the activities of the other. Each complex molecule of matter oscillating as a whole—nay, each separate member of it independently oscillating, causes responsive movements in adjacent ethereal molecules, and these in remoter ones without limit; while, conversely, each ethereal wave reaching a composite molecule, changes more or less its rhythmical motions, as well as the rhythmical motions of its component clusters and those of their separate members.

"Nor do the revelations end here. The discovery that matter, seemingly so simple, is in its ultimate structure so amazingly involved; the discovery that, while it appears to be inert, it is the seat of activities immense in quantity and complication; and the discovery that its molecules, pulsating with almost infinite rapidity, propagate their pulses into the all-surrounding ether which carries them through inconceivable distances in infinitesimal times; serve to introduce us to the yet more marvellous discovery that molecules of each kind are specially affected by molecules of the same kind existing in the farthest regions of space. Units of sodium on which sunlight falls, beat in unison with their kindred units more than ninety millions of miles off, by which the yellow rays of the Sun are produced. Nay, even this is a totally inadequate illustration of the sympathy displayed by the matter composing the visible Universe. The elements of our Earth are thus connected by bonds of interdependent activity, with the elements of stars so remote that the diameter of the Earth's orbit scarcely serves as a unit of measure to express their distances.

"This, then, is the form of being you speak of so contemptuously. And, because I ascribe to this form of being powers which, though not more wonderful than these, are more involved, you scowl at me. If, instead of saying that I degrade Mind to a level with Matter, you were to say that I elevate Matter to a level with Mind, you would express the fact more nearly."

§ 271. Such we may imagine to be the reply of a materialist of the cruder sort, who failed to present his belief under its right aspect. Let us now listen to one of the same general school, whom we may suppose to understand better the meanings of these truths which science has revealed.

"The name you give me is intended to imply that I identify Mind with Matter. I do no such thing. I identify Mind with Motion; and Motion is inconceivable by us as in any sense material. Observe this weight. Now it is motionless; now I relax my grasp and it begins to move towards the Earth. What has suddenly entered into it?

Though apparently unchanged in all its properties, this, or any other mass, needs but to have a quantity of motion impressed on it by impact or otherwise, and it thereafter goes on changing its place in space at the same velocity; so long as it meets with no other matter and has no other motion impressed on it. What is this source of activity? How does it dwell in the weight? and in what manner does it cause the weight to take every instant a new place? On the one hand, we cannot assert that Motion exists as a something separate from Matter; since asserting this implies that we can think of it as having independent attributes. On the other hand, we cannot assert that Motion has no separate existence; since, if it has not, how can we think of it as transferred from one body to another? Moreover, the appearance and disappearance of Motion raise the questions—Where was it previously? and where is it now? When this weight falls, we have not only to ask—Whence has its motion come? but when it strikes the pavement we have to ask—To what place has its motion gone? Part of it was passed on to the particles deranged by the blow; part of it, transformed into sound-waves, has been dispersed through the surrounding air; and, even while I speak, part of it has already travelled millions of miles away in the shape of ethereal undulations. This Motion, then—now diffused and imperceptible, now suddenly individualized and producing visible changes, now re-diffused in various forms and part of it instantly transferred to immeasurable distances—is of a nature wholly inscrutable; and if I identify Mind with it, I identify Mind with something no less mysterious than itself."

"You think of me as seeing no essential difference between Mind and the material properties of brain. As well might I think of you as seeing no essential difference between music and the material properties of the piano from which it is evoked. Because you assert that music is produced from the piano, do you therefore assert any kinship in nature between a piano-string and the ærial pulses it generates when struck? Or do you therefore assert an identity between such pulses and the relations among them which constitute cadences and harmonies? No more then do I, in asserting the dependence of Mind on nervous structure, assert any kinship in nature between the matter of a nerve-cell and the actions that arise from it, or between these actions and those relations among them which constitute thought. Do you object to the parallel because the piano remains silent till touched, while the brain acts without external help? I reply that in either case the power is derived from without, and that the effect of the structure is simply that of transforming it. As the motion given to an automatic musical instrument passes through its specialized structure and comes out in the form of particular combinations of ærial pulses, simultaneous and successive; so the motion locked up in a man's food, added to that directly received through his senses, is transformed while passing through his nervous system into those combinations of nervous actions which, on their subjective faces, are thoughts and feelings.

"But this analogy is far too rude to convey a true conception. Not with sensible Motion, even though it be that of the invisible air, has Mind any direct kinship; but only with insensible Motion, of kinds inconceivably more subtle and immeasurably more rapid. Not to combined undulations of ponderable substance, however rare, is Mind to be assimilated; but only to combined undulations of the all-pervading imponderable substance which we know of only by inference from their effects. The activities of this imponderable substance, though far simpler, and in that respect far lower, than the activities we call Mind, are at the same time far higher than those we call Mind in respect of their intensity, their velocity, their subtlety. What has been gained in adaptability has been lost in vivacity. Though Mind brings into adjustment the apparatus by which certain ethereal undulations emanating from the Sun are brought to a focus, yet Mind cannot, like these concentrated undulations, dissipate the diamond placed in that focus. Though Mind is capable of devising an electric telegraph, yet it remains wholly insensible to those slight molecular agitations on the other side of the Earth which transform themselves into sensible motions on this side. And now that the rates of our ideas and volitions have been measured, we learn that though thought is quick, light is many millions of times quicker.

"Your conceptions, O Spiritualist, is far too gross for me. I know not what may be the extent to which you have refined this creed which you inherit from aboriginal men. Disembodied spirit was conceived by your remote ancestors (as it is still conceived by various existing savages) as material enough to take part in battle, and even to be killed over again. Becoming less concrete and definite as knowledge increased, the idea of a ghost continued, till quite modern days, to be that of a being which could cause alarming noises and utter words. Even your quite-recent ancestors, transparent as they supposed the substance of a ghost to be, nevertheless supposed it visible. Possibly you have still further purified their belief. But whether you confess it or not, you cannot think of disembodied spirit without thinking of it as occupying a separate place in space—as having position, and limits, and such materiality as is implied by limits. This idea, not commended to me by its genealogy, quite unsatisfactory in its nature, and wholly unsupported by evidence, I cannot accept. Mind, I identify with that which is not relatively immaterial but absolutely immaterial. It has not even the inconceivably refined materiality of the ether which fills what you call empty space; but it is assimilable to the activities manifested by this ether, as well as by all sensible forms of being. Everywhere in unceasing influx and efflux, it is that which is for ever dissolving and re-forming sensible existences of all orders—organic and inorganic. Pervading alike the space which is occupied and the space which seems to us unoccupied, it gives to the ponderable substance filling the one its powers of action and reaction, and to the imponderable substance filling the other its powers of conveying actions and reactions from one body to another. So that when there happens some vast catastrophe like that of which the star near ε *Coronæ* was lately the seat, it is at once the agent by which the transformation is wrought and the agent by which is conveyed, with almost infinite speed through the Universe, the resulting tremor felt on the surfaces of its countless worlds."

§ 272. Comparatively consistent as is this answer, and serving though it does to throw back with added force the reproaches of the spiritualist, it is not the answer to be here given. In the closing paragraphs of *First Principles*, and again in the earlier parts of the present work, the position taken was, that the truth is not expressible either by Materialism or by Spiritualism, however modified and however refined. Let me now, for the last time, set forth the ultimate implications of the argument running through this volume, as well as through preceding volumes.

Carried to whatever extent, the inquiries of the psychologist do not reveal the ultimate nature of Mind; any more than do the inquiries of the chemist reveal the ultimate nature of Matter, or those of the physicist the ultimate nature of Motion. Though the chemist is gravitating towards the belief that there is a primitive atom, out of which by variously-arranged unions are formed the so-called elements, as out of these by variously-arranged unions are formed oxides, acids, and salts, and the multitudinous more complex substances; yet he knows no more than he did at first about this hypothetical primitive atom. And similarly, though we have seen reason for thinking that there is a primitive unit of consciousness, that sensations of all orders are formed of such units combined in various relations, that by the compounding of these sensations and their various relations are produced perceptions and ideas, and so on up to the highest thoughts and emotions; yet this unit of consciousness remains inscrutable. Suppose it to have become quite clear that a shock in consciousness and a molecular motion, are the subjective and objective faces of the same thing; we continue utterly incapable of uniting the two, so as to conceive that reality of which they are the opposite faces. Let us consider how either face is framed in our thoughts.

The conception of a rhythmically-moving mass of sensible matter, is a synthesis of certain states of consciousness that stand related in a certain succession. The conception of a rhythmically-moving molecule, is one in which these states and their relations have been reduced to the extremest limits of dimension representable to the mind, and are then assumed to be further reduced far beyond the limits of representation. So that this rhythmically-moving molecule, which is our unit of composition of external phenomena, is mental in a three-fold sense—our experiences of a rhythmically-moving mass, whence the conception of it is derived, are states of mind, having objective counterparts that are unknown; the derived conception of a rhythmically-moving molecule, is formed of states of mind that have no directly-presented objective counterparts at all; and when we try to think of the rhythmically-moving molecule as we suppose it to exist, we do so by imagining that we have re-represented these representative states, on an infinitely-reduced scale. So that the unit out of which we build our interpretation of material phenomena, is triply ideal.

On the other hand, what are we to think of this ideal unit, considered as a portion of Mind? It arises, as we have seen, by synthesis of many feelings, real and ideal, and of the many changes among them. What are feelings? What is changed? And what changes it? If to avoid obvious implications of a materiality, we call each element of this ideal unit, a state of consciousness, we only get into other similar implications. The conception of a state of consciousness implies the conception of an existence which has the state. When on decomposing certain of our feelings we find them formed of minute shocks, succeeding one another with different rapidities and in different combinations; and when we conclude that all our feelings are probably formed of such units of consciousness variously combined, we are still obliged to conceive this unit of consciousness as a change wrought by some force in something. No effort of imagination enables us to think of a shock, however minute, except as undergone by an entity. We are compelled, therefore, to postulate a substance of Mind that is affected, before we can think of its affections. But we can form no notion of a substance of Mind absolutely divested of attributes connoted by the word substance; and all such attributes are abstracted from our experiences of material phenomena. Expel from the conception of Mind every one of those attributes by which we distinguish an external something from an external nothing, and the conception of Mind becomes nothing. If to escape this difficulty we repudiate the expression "state of consciousness," and call each undecomposable feeling "a consciousness," we merely get out of one difficulty into another. A consciousness, if not the state of a thing is itself a thing. And as many different consciousnesses as there are, so many different things there are. How shall we think of these so many independent things, having their differential characters, when we have excluded all conceptions derived from external phenomena? We can think of entities that differ from one another and from nonentity, only by bringing into our thoughts the remembrances of entities which we distinguished as objective and material. Again, how are we to conceive these consciousnesses as either being changed one into another or as being replaced one by another? We cannot do this without conceiving of cause; and we know nothing of cause save as manifested in existences we class as material—either our own bodies or surrounding things.

See then our predicament. We can think of Matter only in terms of Mind. We can think of Mind only in terms of Matter. When we have pushed our explorations of the first to the uttermost limit, we are referred to the second for a final answer; and when we have got the final answer of the second we are referred back to the first for an interpretation of it. We find the value of x in terms of y; then we find the value of y in terms of x; and so on we may continue for ever without coming nearer to a solution. The antithesis of subject and object, never to be transcended while consciousness lasts, renders impossible all knowledge of that Ultimate Reality in which subject and object are united.

§ 273. And this brings us to the true conclusion implied throughout the foregoing pages—the conclusion that it is one and the same Ultimate Reality which is manifested to us subjectively and objectively. For while the nature of that which is manifested under either form proves to be inscrutable, the order of its manifestations throughout all mental phenomena proves to be the same as the order of its manifestations throughout all material phenomena.

The Law of Evolution holds of the inner world as it does of the outer world. On tracing up from its low and vague beginnings the intelligence which becomes so marvellous in the highest beings, we find that under whatever aspect contemplated, it presents a progressive transformation of like nature with the progressive transformation we trace in the Universe as a whole, no less than in each of its parts. If we study the development of the nervous system, we see it advancing in integration, in complexity, in definiteness. If we turn to its functions, we find these similarly show an ever-increasing inter-dependence, an augmentation in number and heterogeneity, and a greater precision. If we examine the relations of these functions to the actions going on in the world around, we see that the correspondence between them progresses in range and amount, becomes continually more complex and more special, and advances through differentiations and integrations like those everywhere going on. And when we observe the correlative states of consciousness, we discover that these, too, beginning as simple, vague, and incoherent, become increasingly-numerous in their kinds, are united into aggregates which are larger, more multitudinous, and more multiform, and eventually assume those finished shapes we see in scientific generalizations, where definitely-quantitative elements are co-ordinated in definitely-quantitative relations.

Such are the results of a synthesis which we shall presently find verified by analysis. These are the conclusions to which Objective Psychology has brought us; and these are the conclusions to which we shall find ourselves led by that Subjective Psychology to which we now pass.

APPENDIX.

APPENDIX.

ON THE ACTIONS OF ANÆSTHETICS AND NARCOTICS.

WHILE omitting them from the text, I cannot refrain from here appending certain conclusions respecting the actions of Anæsthetics and Narcotics, to which I have been led while seeking an explanation of the anomalies referred to.

It is commonly supposed that these agents have special relations to nervous tissue, rather than to other tissues; and, because of the different effects they work, it is even assumed that some of them have elective affinities for the matter composing certain nervous centres rather than for that composing others. This last supposition, made without other warrant than that it renders certain of the facts intelligible, must be carried much further to account for all the facts. As the same anæsthetic does not act in the same way on all persons, but here affects one centre more and here another, it must be assumed that the chemical compositions of these centres are in such cases interchanged—nay, as one drunken man becomes morose while another becomes affectionate, it must be supposed that different parts of the cerebral hemispheres have in such cases interchanged their chemical compositions. Nor is even this the extreme of the difficulty. For since in the same individual, the same quantity of the same anæsthetic will produce quite different effects in different states of the circulation; the hypothesis requires us to suppose that these contrasts of chemical composition among the nervous centres interchange from hour to hour.

If instead of a gratuitous assumption that leaves many of the effects unaccounted for, we make an assumption that is not gratuitous and renders the facts, general and special, intelligible, there cannot be a doubt which of the two is preferable. Setting out, then, with the generalization that these various substances that affect the nervous system—the vegeto-alkalies, the alcohols and ethers, nitrous oxide, ammonia, arsenic, the mineral acids, &c.—are substances that produce changes in albuminous matters, let us consider how their respective effects will be modified by the various conditions under which they act. Agents having powerful affinities for components of the tissues and fluids, given in small quantities to avoid destruction of the membranes, can scarcely reach the nervous system in uncombined states; and may be expected to work their respective effects through the instrumentalities of the compounds they have formed. The most conspicuous effects will be wrought by those agents which, while they can produce molecular changes in albuminous substances, have not such powerful affinities for them, or for their elements, as to be arrested on their way to the nervous system. The anæsthetics and narcotics may fairly be regarded as fulfilling this requirement. So much being premised, let us ask what will be the influences of such substances carried indiscriminately through the body and acting indiscriminately on the tissues. If a blood-corpuscle, or a bile-cell, or a particle of mucous membrane, is affected by ether or by opium, and changed isomerically or otherwise, the implied molecular disturbance works little or no effect on the body at large, in the absence of a channel through which the disturbance can be conducted. But if the ether or opium affects a molecule of a nerve-corpuscle, the line of isomerically-changing molecules connected with the nerve-corpuscle, conveys the disturbance to some remote place; whence, by diffusion and re-diffusion, it is carried through the nervous system as a whole. That is to say, we need not suppose the anæsthetic or narcotic to have more affinity for the protein-substance of nerve-corpuscle or nerve-fibre, than for the other forms of protein-substance it comes in contact with; but its effect is comprehensible as resulting from the structural relations of nerve-corpuscle and nerve-fibre.

Carrying with us this conception, and not assuming that the anæsthetic or narcotic has any elective affinity for the matter of one nerve-corpuscle rather than for that of another, or for nerve-corpuscle rather than for nerve-fibre, let us consider what further differences in its actions will be entailed by further differences in the conditions of the parts. We have experimental proof that an agent which arrests the function of nerve, serves at the moment of its action to excite nerve. If nerve is cut in two, or constricted by a ligature, or seared, or touched by a powerful acid, it is, in the act of being incapacitated, made to convey a strong discharge. We have reason to expect, then, that whatever agent so acts on nerve-substance as to disable it, will, in working the implied molecular change, cause a molecular disturbance constituting excitement. To understand fully, however, why stimulation precedes narcosis, we must observe the different relations of nerve-corpuscles and nerve-fibres to the blood.

As pointed out when treating of the nervous system, its vesicular tissue is far more vascular than its fibrous tissue; and further, while the matter of nerve-vesicles is so arranged as to offer the least possible obstacle to the reception of fluid from the adjacent capillaries, the matter of nerve-fibres is shielded by a medullary sheath. Hence, when any agent capable of so changing the molecular state of nerve-matter as to arrest its function, is carried into the blood, it first acts on the nerve-corpuscles. Each change produced in one of these (be it the decomposition of a molecule or, as is more probable, the isomeric transformation of a molecule) implies a disengagement of molecular motion, that is immediately propagated along the connected nerve-fibres, and excites the parts to which they run. Every nerve-corpuscle being thus quickly acted upon, and emitting successive discharges as the successive molecular transformations are wrought in it, there results a general exaltation of state; as shown physically in the invigorated pulse and contractions of the muscles, and as shown psychically in the rush of vivid ideas and intensified feelings. But what is taking place with the rest of the nervous system? While some molecules of alcohol or ether or chloroform, as the case may be, have thus quickly passed from the closely-adjacent capillaries into the almost naked matter of the nerve-corpuscles, other such molecules are elsewhere on their way through the outer coats of the nerve-tubes and the medullary sheaths within these; and they presently reach the bundle of fibrillæ forming the axis cylinders. It may be concluded that the isomeric changes they immediately begin to produce in these, at first add to the general excitement. Though each molecule changed is thereafter incapacitated for taking part in the transfer of a nerve-wave; yet in the act of being changed, it becomes itself the initiator of a nerve-wave. Be this as it may, however, we must infer that as the anæsthetic invades a nerve-fibre more and more, a greater and greater number of its molecules are rendered unable to transfer a wave of the peculiar isomeric change which constitutes a nervous discharge; and, eventually, the fibre becomes impermeable.

Observe, now, the several implications. We have first an explanation of the fact that, other things being equal, the longer nerve-fibres become impermeable sooner than the shorter. Assuming, as we may fairly do, that all the nerves conveying sensations of touch are equally permeable, it will naturally happen that at the expiration of a given interval, the probability that a nerve fibre has been at some part of its course invaded by the anæsthetic, will be greater if the fibre is long than if it is short. Hence the fact that anæsthesia occurs first in the hinder extremities; and that parts of the surface nearer to the nervous centres lose their sensibility later.*

We are enabled also to account for those diversities of results produced by different doses and by the same dose under different conditions. Reaching easily the vesicular elements of the nervous system, and with more difficulty the fibrous elements, a small

* It is true that, according to Dr. Anstie, dogs and rats experimented upon, early lose sensation in the muzzle; but here the natural anæsthesia due to the coldness caused by constant evaporation, aids the artificial anæsthesia.

quantity of one of these substances introduced into the blood, will have a stimulating effect little if at all qualified by the anæsthetic effect. Obviously, too, the conflict between these opposite actions —the one tending to increase the genesis of nervous fluid and the other tending to block up the channels for its discharge—will, other things equal, end in predominance of the one or the other according to the state of the circulation, general or local. If the blood is rapidly propelled, so as to bring to the nervous centres an abundant supply not only of the exciting agent but of the materials which further waste and repair, the increased amount of nervous fluid generated, may more than compensate for decrease in the facility of its transfer along the nerves; and this may especially be expected to happen where, in addition to an active general circulation, the circulation through the brain as a whole, or through some of its plexuses, is much exalted. On the other hand, as the anæsthetic, once diffused through the system, will invade the nerve-fibres in much the same way whether the blood moves slowly or quickly, there will, when it moves slowly, result an impediment to nervous discharge without any augmented pressure of nervous fluid, and hence the sedative influence will predominate. The contrasts between different persons, and different states of the same person, as affected by these agents, thus become intelligible.

"But how are we to explain the unlike effects produced on the nervous system by unlike agents? Should not all anæsthetics and narcotics have the same effects?" I reply in the first place, that much as these various agents, swallowed or inhaled or injected, differ in their minor results, they *do* agree in their major results, as being excitants or sedatives according to circumstances, and as habitually producing exaltation of function before depression of function, when the dose is sufficient to produce depression. In the second place, I reply that while there are doubtless many more special causes of differences in their actions, there is one conspicuous general cause—their greater or less molecular mobility, and consequent greater or less diffusibility through the tissues. From this arises the generic contrast between the actions of anæsthetics and narcotics. As compared with the vegeto-alkalies, &c., the alcohols, ethers, &c., are substances of much lower molecular complexity, which show by their readiness to assume the gaseous form how much more diffusible they are. Bearing in mind the researches of Prof. Graham, we may fairly infer that molecules of nitrous oxide, or ether, or chloroform, pass through the walls of the blood-vessels and the protective coats of the nerve-fibres, much more rapidly than do molecules of morphia, or of that component to which hashish owes its power. And if so, it must naturally happen that while the stimulant effects of the anæsthetics will be very quickly shown and soon followed by the paralyzing effects, the stimulant effects of the narcotics, less quickly shown, will be less quickly followed by the paralyzing effects. It may be suspected, too, that among the anæsthetics themselves and among the narcotics themselves, many such unlikenesses of action must result from unlikenesses of diffusibility. Indeed, suspicion rises almost to certainty on remembering how the most diffusible anæsthetics not only rapidly act but rapidly cease to act, in consequence of their speedy elimination from the system.

It is quite possible, then, that the various effects worked by these various agents, all result from specialities of co-operation among the many factors. Let me briefly enumerate these factors:—1. The place at which the agent is absorbed, and the consequent ability of the agent to act on some parts of the nervous system sooner than on others. 2. The rapidity of absorption; which, if great, will make possible a marked local effect before a marked general effect. 3. The quantity absorbed, as sufficient to act on nerve-vesicle without appreciably affecting nerve-fibre, or as sufficient to appreciably affect both. 4. The relative molecular mobility of the agent. 5. Its chemical relations to the blood, (*a*) as affecting its power of carrying gases, (*b*) as affecting its various components in such ways as to aid or hinder waste or nutrition. 6. Its chemical relations to the substances passed through (more especially to the medullary substance covering nerve-fibre) which will aid or hinder its paralyzing effect. 7. The general state of the circulation. 8. The state of the circulation in each nervous centre, as ordinary or as excited by function. 9. The characters of the nerve-fibres acted upon, as differing (*a*) in length, (*b*) in ability to convey discharges with facility, (*c*) in amount of protective covering, (*d*) in proximity to many or few capillaries. Here, then, are a dozen factors, the co-operation of which will not be the same in any two cases; and unlike primary combinations of them may cause endlessly-varied secondary combinations—as when, for example, the vaso-motor nerves of one centre are acted on sooner than on those of another, thus complicating the effects by altering the relative supplies of blood to these centres. It is not necessary, then, to assign elective affinities for special centres as the only possible causes of the special effects. This hypothesis should, I think, be resorted to only when other modes of interpretation are proven inadequate.

CONSCIOUSNESS UNDER CHLOROFORM.

A University graduate whose studies in Psychology and Philosophy have made him an observer able to see the meanings of his experiences, has furnished me with the following account of the feelings and ideas that arose in him during loss of consciousness and during return to consciousness. My correspondent, describing himself as extremely susceptible to female beauty, explains that "the girl" named in the course of the description was an unknown young lady in the railway carriage which brought him up to town to the dentist's. He says his system resisted the influence of chloroform to such a degree, that it took twenty minutes to produce insensibility: the result being that for a much longer time than usual he underwent partial hyperæsthesia instead of anæsthesia. After specifying some dreadful sensations which soon arose he goes on to say:— * * * I began to be terrified to such a wonderful extent as I would never before have guessed possible. I made an involuntary effort to get out of the chair, and then—suddenly became aware that I was looking at nothing: while taken up by the confusion in my lungs, the outward things in the room had gone, and I was "alone in the dark." I felt a force on my arm (which did not strike me as the surgeon's "hand," but merely as an external restraint) keeping me down, and this was the last straw which made me give in, the last definite thing (smell, sound, sight, or touch) I remembered outside my own body. Instantly I was seized and overwhelmed by the panic inside. I could feel every air-cell struggling spasmodically against an awful pressure. In their struggle they seemed to tear away from one another in all directions, and there was universal racking torture, while meantime the common foe, in the shape of this iron pressure, kept settling down with more and more irresistible might into every nook and crevice of the scene. My consciousness was now about this: I was not aware of anything but an isolated scene of torture, pervaded by a hitherto unknown sense of terror (and by what I have since learnt is called "the unity of consciousness:" this never deserted the scene, even down to the very last inaudible heart-beat). Yet I call it a "scene," because I recognized some different parts of my body, and felt that the pain in one part was not the same as that in another. Meanwhile, along with the increased intensity of convulsion in my lungs, an element of noise had sprung up. A chaotic roaring ran through my brain, innumerable drums began to beat far inside my ear, till the confusion presently came to a monstrous thudding, every thud of which wounded me like a club falling repeatedly on the same spot. * * *

From this stage my lungs ceased to occupy me, and I forget how the struggle finished. There was a sense of comparative relief that, at any rate, *one* force was victorious, and the distraction over; the strange large fright that had seized me so entirely when I felt myself ensnared into dark suffocation was now gone also, and there was only left the huge thudding at my ears, and the terribly impetuous stroke of my heart. The thudding gradually got less acutely painful, and less loud; I remember a recognition of satisfaction that one more fearful disturbance was gone. But, while the thunder in my ear was thus growing duller, all of a sudden my heart sprang out with a more vivid flash of sensation than any of those previous ones. The force of an express engine was straining there, and like a burning ball it leapt from side to side, faster and faster, hitting me with such a superhuman earnestness that I felt each time as if the iron had entered my soul, and it was all over with me for ever. (Not that "I" was now any more than this burning-hot heart and the walled space in which it was making its strokes: the rest of "me" had gone unobserved out of focus.) Every stroke produced exquisite pain on the flesh against which it beat glowing, and there was a radiation, as from a molten lump of metal between enclosures. Presently the unbearable heat got less, and there was nothing remaining except a pendulous movement, slackening speed, and not painful. Of nothing beyond was I conscious but this warm body vibrating: not a single other part of me was left, and there was not a single other movement of any sort to attract my attention. A fading sense of infinite leisure at last, in a dreamy inaudible air; then all was hushed out of notice.

* * There was the breaking of a silence that might have been going on for ever in the utterly dark air. An undisturbed empty quiet was everywhere, except that a stupid presence lay like a heavy intrusion *somewhere*,—a blotch on the calm. This blotch became more inharmonious, more distinctly leaden; it was a heavier pressure,—it is actually intruding further,—and before almost there was time to wonder feebly how disagreeable was this interruption of untroubled quiet, it had loomed out as something unspeakably cruel and woeful. For a bit there was nothing more than this profoundly cruel presence, and my recognition * of it. It seemed unutterably monstrous in its nature, and I felt it like some superhuman injustice; but so entire had been the still rest all round before its shadow troubled me, that I had no notion of making the faintest remonstrance. * * * It got worse. * * * Just as the cruelty and injustice became so unbearable that I hardly

* If there were a noun belonging to the verb "To be aware of," like "recognition" to "recognize," it would be the one to use here.

could take it in, suddenly it came out a massive, pulsating *pain*, and I was all over one tender wound, with this dense pain probing me to my deepest depths. I felt *one* sympathetic body of atoms, and at each probe of the pain every single atom was forced by a tremendous pressure into all the rest, while everyone of them was acutely tender, and shrank from the wound—only there was nowhere to shrink. A little before, I had merely *felt* the cruel element, in helpless passivity; now, a still more crushing probe came; for an instant it forced all my atoms into one solid steel-mass of intense agony—then, when things couldn't go much further, and all must be over, a sense of reaction emerged; there was a loosening, and I was urged into relief by uttering from my very depths, what seemed not so much (at first) a piteous remonstrance as a piteous "expression" (like an imitation) of the pain: in fact, the sense of woe had got also *outside*, and I *heard* it, a very low, infinitely genuine, moan. * * The next second there was a change: hitherto it had been pain *partout*—now there came a quick concentration, the pain all ran together (like quicksilver), and I suddenly was aware that it was (localized) *up on the right;* while, simultaneously with this recognition of locality, a feeling of incipient *resistance* began to be in *other parts* (not that I felt them except just as *other* parts) of me from which the pain had receded. The pain itself was no less intense, rather more vivid, only I seemed to take it in a more *lively* manner: my uttering of a moan was no longer a mere faithful representation out into the air of what was inside me, but I had a slight sense of making an appeal for sympathy: to whom or to what I did not know, for there was no one or anything there. I was just going to utter a yet louder moan—as a fresh fearful imposition of force plunged into me—when, there in front of me, to the *left* of my pain, was that girl, with those lovely ankles, and the graceful Zingari brown stockings. * * I felt, as distinctly as if some had told me aloud, that I would not make any cry, that it was not the thing.

Now came an agonizing cold wrench, and two or three more successively, in such a hideously rough fashion, that the girl went, and everything was tortured out of me but the darkness and the gigantic racking swaying torture which was excruciating my right side. An iron force like a million-horsepower had hold of me, and I was being pulled upwards and out of where I was, while I myself seemed another million-horsepower which would *not* be pulled: the pain was something to be remembered. But up I came, the darkness got denser (I went so fast); it was vibrating, the dense agony vibrated faster; *I* was quivering, struggling, kicking out; everything was a convulsion of torture, my head seemed to come to the surface, a glimpse of light and air broke on the darkness, voices came through to me, and words; I recognized that a "*tooth*" was being slowly twisted out of my jaw, then I groaned imploringly, in true earthly style, as if this was *too much*, and I ought to be let alone now I was getting my "head" out; then I swallowed in air, made an exertion with my "chest," found my "arms" were pressing something hard, grasped the "chair," and pushed myself up out in bewildered light, just as the dentist threw away the second right molar from the upper jaw.

Concerning this account it may be remarked, on the one hand, that the higher consciousness seems not to have been wholly abolished; since there remained certain emotions and certain most general ideas of relation to objective agents. On the other hand it is to be doubted whether the partial consciousness which the narrator had during anæsthesia, is not, in the description, eked out in some measure by the ideas of his recovered consciousness carried back to them. Be this as it may, however, it is clear that certain components of consciousness disappeared and others became extremely vague, while a remainder continued tolerably distinct. And there is much significance in the relations among them:— 1. There ceased earliest the sensations derived from the special senses; then the impression of force acting on the body from without; and, simultaneously, there ceased the consciousness of external space-relations. 2. There remained a vague sense of relative position within the body; which, gradually fading, left at last only a sense of those space-relations implied by consciousness of the heart's pulsations. 3. And this cluster of related sensations produced by the heart's action, finally constituted the only remaining distinct portion of the *Ego*. 4. In the returning consciousness we note first a sense of pressure *somewhere:* there was no consciousness of space-relations within the body. 5. The consciousness of this was not a cognition proper. In an accompanying letter my correspondent says of it:—"'Recognition' seems to imply installation in some previously-formed concept (talking in the Kantian way), and this is just what was *not* the case:" that is, consciousness was reduced to a state in which there was not that classing of states which constitutes thought. 6. The pain into which the pressure was transformed was similarly universal instead of local. 7. When the pain became localized, its position in space was vague: it was "up on the right." 8. Concerning the apparition of "the girl," which, as my correspondent remarks, seems to have occurred somewhat out of the probable order, he says, in a letter: —"I did not recognize her 'under any concept'—what I saw seemed to be almost unassisted intuition in the Kantian sense." 9. The localization of the pain was at first the least possible—the consciousness was of that part *versus* all other parts unlocalized.

These experiences furnish remarkable verifications of certain doctrines set forth in this work. This degradation of consciousness by chloroform, abolishing first the higher faculties and descending gradually to the lowest, may be considered as reversing that ascending genesis of consciousness which has taken place in the course of evolution; and the stages of descent may be taken as showing, in opposite order, the stages of ascent. It is significant, therefore, that impressions from the special senses ceasing early, leave behind as the last impression derived from without, the sense of outer force conceived as opposed by inner resistance; for this we saw to be the primordial element of consciousness. (§ 347.) Again, the fact that the consciousness of external space disappeared simultaneously with the consciousness of external force, answers to the conclusion drawn that space-ideas are built out of experiences of resistant positions, the relations among which are measured by sensations of muscular effort. (§ § 343, 348.) Further there is meaning in the fact that a vague sense of relative position within the body survived; since we concluded that by mutual exploration there is gained that knowledge of the relations among the parts of the body, which gives measures through which the developed knowledge of surrounding space is reached. (§ § 344, 345.) Once more we get evidence that the *Ego* admits of being progressively shorn of its higher components, until, finally, the sensations produced by the beating of the heart, remain alone to constitute the conscious self: showing in the first place, that the conscious self at any moment is really compounded of all the states of consciousness, presentative and representative, then existing (§ 219), and showing in the second place, that it admits of being simplified so far as to lose most of the elements composing the consciousness of corporeal existence. Whence it is inferable that self-consciousness begins as a mere rudiment consisting of present sensations, without past or future. Lastly, we have the striking testimony that there exists a form of consciousness lower than that which the lowest kind of thought shows us. The simplest intellectual act implies the knowing something as such or such—implies the consciousness of it as like something previously experienced, or, otherwise, as belonging to a certain class of experiences. But we here get evidence of a stage so low that a received impression remains in consciousness unclassed: there is a passive reception of it, and an absence of the activity required to know it as such or such.

NOTE TO CHAPTER VIII. OF PART IV.

In his *Principles of Mental Physiology*, Dr. Carpenter, referring to the doctrine of mental evolution as caused by the inherited effects of experiences, developed in the foregoing chapters, says:—

"But it has been distinctly foreshadowed as regards the Instincts of animals (which are only lower forms of Man's intellectual Intuitions) by Sir John Sebright, Mr. T. A. Knight, and M. Roulin; of whose observations a summary has been given by the Writer in the *Contemporary Review*, January, 1873. * * * And in the Fourth and Fifth Editions of his 'Human Physiology,' published respectively in 1852 and 1855, the Writer had distinctly expressed his belief that the Cerebrum of Man *grows to the modes of thought in which it is habitually exercised; and that such modifications in its structure are transmissible hereditarily.* * * * He here refers to this fact, merely to show that the *general doctrine* above enunciated * * * is much older than Mr. Herbert Spencer."

Communications to which the above passage led, disclosed the fact that Dr. Carpenter had not read this work; but had, as I understood, purposely refrained from doing so. I pointed out to him the difference between the proposition that transmitted mental modifications produce varieties of mental faculty *within the limits of a species;* and the proposition that Mind, in all its faculties, is produced by transmissions of such modifications through all the successions of species during the evolution of life upon the Earth. After obtaining from Dr. Carpenter the admission that this latter proposition had not even been entertained (much less elaborated into a system) by those he names, I concluded that he would, in his next edition, alter the above statement. He has not done this, however; and therefore, somewhat reluctantly, I must myself point out the grave misrepresentations it embodies.

Manifestly no one can entertain the belief that the psychical powers of all creatures have arisen by evolution, without tacitly or avowedly committing himself to the belief that their physical structures have arisen by evolution. Dr. Carpenter is fully aware that in 1855, when the first edition of this work was published, the "development-hypothesis," as it was then commonly called, was repudiated by men of science, as well as by the world at large; and further, that any one who held it exposed himself to the ridicule of the scientific. He does not allege that those he names believed it; much less gave a public adhesion to it. Yet now, in the above passage, he asserts that he and others had enunciated in a general way, the doctrine elaborated in this work: they avowed a conclusion the necessary premises of which they did not admit!

Either Dr. Carpenter is still in the position of not having read this work, or he has read it since the time above referred to. If he has not read it, then it is strange that he should undertake to correct the impressions of "younger readers," concerning the relation between its views and the views previously held (see *Contemporary Review*, for February, 1875). If he has read it, then it is even more strange that he should persist in the above statement. In the first place, he must have become aware that the facts and inferences named by him, as current before this work was written, are referred to in this work as familiar—are taken as established (§ 180, in edition of 1855); not propounded as new. In the second place, he must have seen that these facts and inferences are used as part of my data—that my reasonings begin where the reasonings he names leave off. And yet having seen this, he identifies the theory that mental modifications within the limits of a species are producible by inherited effects of experiences, with the theory that the genesis of all mental faculties, down to forms of thought, have been thus produced. He alleges previous currency of the "general doctrine." It seems to me that his ideas of *general* and *special* are no less remarkable than his idea of identity. The proposition that such changes of dog-nature as a pointer's habits show, arise by inherited mental modifications, would commonly be thought a special proposition; while the proposition that by inherited modifications there has been an evolution of Mind in all its modes, from reflex action up to abstract reason and moral sentiment, would commonly be thought a general proposition. But Dr. Carpenter thinks the contrary. Doubtless, in pursuance of the same view, he regards the doctrine that pigeons and other domestic animals may have their structures modified by selection, as a "general" one; and the doctrine of Mr. Darwin, that all structures of all animals are caused by natural selection, as a special one. For the two cases are perfectly similar. Between the idea that structural changes are producible within the limits of a species by selection, and the idea that all organization is thus producible, there is a relation exactly parallel to the relation between the idea that the instincts of a species may be changed by inherited effects of experiences, and the idea that all mental organization is producible by the inherited effects of experiences.

Hence, we may expect that when next Dr. Carpenter refers to the hypothesis of "natural selection," he will point out that it had been distinctly foreshadowed by Sir John Sebright, Mr. Youatt, and others; and after quoting passages from their writings, will remark that he does so "merely to show that the *general doctrine*" "is much older than" Mr. Darwin.