顶级思想大师的传世经典

THE PRINCIPLES OF PSYCHOLOGY

心理学原理

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田平 ⊙ 译

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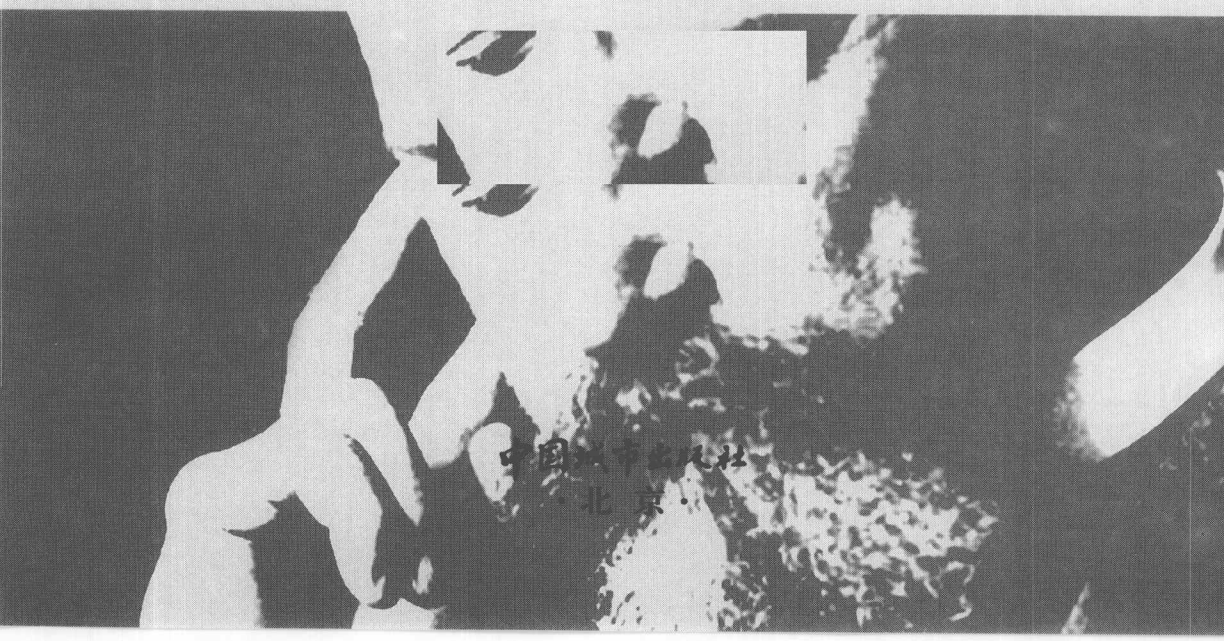

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Preface

The treatise which follows has in the main grown up in connection with the author's class-room instruction in Psychology, although it is true that some of the chapters are more 'metaphysical,' and others fuller of detail, than is suitable for students who are going over the subject for the first time. The consequence of this is that, in spite of the exclusion of the important subjects of pleasure and pain, and moral and aesthetic feelings and judgments, the work has grown to a length which no one can regret more than the writer himself. The man must indeed be sanguine who, in this crowded age, can hope to have many readers for fourteen hundred continuous pages from his pen. But *wer Vieles bringt wird Manchem etwas bringen*; and, by judiciously skipping according to their several needs, I am sure that many sorts of readers, even those who are just beginning the study of the subject, will find my book of use. Since the beginners are most in need of guidance, I suggest for their behoof that they omit altogether on a first reading chapters 6, 7, 8, 10 (from page 330 to page 371), 12, 13, 15, 17, 20, 21, and 28. The better to awaken the neophyte's interest, it is possible that the wise order would be to pass directly from chapter 4 to chapters 23, 24, 25, and 26, and thence to return to the first volume again. Chapter 20, on Space-perception, is a terrible thing, which, unless written with all that detail, could not be fairly treated at all. An abridgment of it, called 'The Spatial Quale,' which appeared in the Journal of Speculative Philosophy, vol. XIII. p. 64, may be found by some persons a useful substitute for the entire chapter.

I have kept close to the point of view of natural science throughout the book. Every natural science assumes certain data uncritically, and declines to challenge the elements between which its own 'laws' obtain, and from which its own deductions are carried on. Psychology, the science of finite individual minds, assumes as its data (1) *thoughts and feelings*, and (2) *a physical world* in time and space with which they coexist and which (3) *they know*. Of course these data themselves are discussable; but the discussion of them (as of other elements) is called metaphysics and falls outside the province of this book. This book, assuming that thoughts and feelings exist and are vehicles of knowledge, thereupon contends that psychology when she has ascertained the empirical correlation of the various sorts of thought or feeling with definite conditions of the brain, can go no farther—can go no farther, that is, as a natural science. If she goes farther she becomes metaphysical. All attempts to *explain* our phenomenally given thoughts as products of deeper-lying entities (whether the latter be named 'Soul,' 'Transcendental Ego,' 'Ideas,' or 'Elementary Units of Consciousness') are metaphysical. This book consequently rejects both the associationist and the spiritualist theories; and in this strictly positivistic point of view consists the only feature of it for which I feel tempted to claim originality. Of course

this point of view is anything but ultimate. Men must keep thinking; and the data assumed by psychology, just like those assumed by physics and the other natural sciences, must some time be overhauled. The effort to overhaul them clearly and thoroughly is metaphysics; but metaphysics can only perform her task well when distinctly conscious of its great extent. Metaphysics fragmentary, irresponsible, and half-awake, and unconscious that she is metaphysical, spoils two good things when she injects herself into a natural science. And it seems to me that the theories both of a spiritual agent and of associated 'ideas' are, as they figure in the psychology-books, just such metaphysics as this. Even if their results be true, it would be as well to keep them, *as thus presented*, out of psychology as it is to keep the results of idealism out of physics.

I have therefore treated our passing thoughts as integers, and regarded the mere laws of their coexistence with brain-states as the ultimate laws for our science. The reader will in vain seek for any closed system in the book. It is mainly a mess of descriptive details, running out into queries which only a metaphysics alive to the weight of her task can hope successfully to deal with. That will perhaps be centuries hence; and meanwhile the best mark of health that a science can show is this unfinished-seeming front.

The completion of the book has been so slow that several chapters have been published successively in Mind, the Journal of Speculative Philosophy, the Popular Science Monthly, and Scribner's Magazine. Acknowledgment is made in the proper places.

The bibliography, I regret to say, is quite unsystematic. I have habitually given my authority for special experimental facts; but beyond that I have aimed mainly to cite books that would probably be actually used by the ordinary American college-student in his collateral reading. The bibliography in W. Volkmann von Volkmar's Lehrbuch der Psychologie (1875) is so complete, up to its date, that there is no need of an inferior duplicate. And for more recent references, Sully's Outlines, Dewey's Psychology, and Baldwin's Handbook of Psychology may be advantageously used.

Finally, where one owes to so many, it seems absurd to single out particular creditors; yet I cannot resist the temptation at the end of my first literary venture to record my gratitude for the inspiration I have got from the writings of J. S. Mill, Lotze, Renouvier, Hodgson, and Wundt, and from the intellectual companionship (to name only five names) of Chauncey Wright and Charles Peirce in old times, and more recently of Stanley Hall, James Putnam, and Josiah Royce.

HARVARD UNIVERSITY, August 1890.

CHAPTER I
The Scope of Psychology

Psychology is the Science of Mental Life, both of its phenomena and their conditions. The phenomena are such things as we call feelings, desires, cognitions, reasonings, decisions, and the like; and, superficially considered, their variety and complexity is such as to leave a chaotic impression on the observer. The most natural and consequently the earliest way of unifying the material was, first, to classify it as well as might be, and, secondly, to affiliate the diverse mental modes thus found, upon a simple entity, the personal Soul, of which they are taken to be so many facultative manifestations. Now, for instance, the Soul manifests its faculty of Memory, now of Reasoning, now of Volition, or again its Imagination or its Appetite. This is the orthodox 'spiritualistic' theory of scholasticism and of common-sense. Another and a less obvious way of unifying the chaos is to seek common elements *in* the divers mental facts rather than a common agent behind them, and to explain them constructively by the various forms of arrangement of these elements, as one explains houses by stones and bricks. The 'associationist' schools of Herbart in Germany, and of Hume, the Mills and Bain in Britain, have thus constructed a *psychology without a soul*by taking discrete 'ideas,' faint or vivid, and showing how, by their cohesions, repulsions, and forms of succession, such things as reminiscences, perceptions, emotions, volitions, passions, theories, and all the other furnishings of an individual's mind may be engendered. The very Self or *ego*of the individual comes in this way to be viewed no longer as the pre-existing source of the representations, but rather as their last and most complicated fruit.

Now, if we strive rigorously to simplify the phenomena in either of these ways, we soon become aware of inadequacies in our method. Any particular cognition, for example, or recollection, is accounted for on the soul-theory by being referred to the spiritual faculties of Cognition or of Memory. These faculties themselves are thought of as absolute properties of the soul; that is, to take the case of memory, no reason is given why we should remember a fact as it happened, except that so to remember it constitutes the essence of our Recollective Power. We may, as spiritualists, try to explain our memory's failures and blunders by secondary causes. But its *successes*can invoke no factors save the existence of certain objective things to be remembered on the one hand, and of our faculty of memory on the other. When, for instance, I recall my graduation-day, and drag all its incidents and emotions up from death's dateless night, no mechanical cause can explain this process, nor can any analysis reduce it to lower terms or make its nature seem other than an ultimate *datum*, which, whether we rebel or not at its mysteriousness, must simply be taken for granted if we are to psychologize at all. However the associationist may represent the present ideas as

thronging and arranging themselves, still, the spiritualist insists, he has in the end to admit that *something*, be it brain, be it 'ideas,' be it 'association,' *knows* past time *as* past, and fills it out with this or that event. And when the spiritualist calls memory an 'irreducible faculty,' he says no more than this admission of the associationist already grants.

And yet the admission is far from being a satisfactory simplification of the concrete facts. For why should this absolute god-given Faculty retain so much better the events of yesterday than those of last year, and, best of all, those of an hour ago? Why, again, in old age should its grasp of childhood's events seem firmest? Why should illness and exhaustion enfeeble it? Why should repeating an experience strengthen our recollection of it? Why should drugs, fevers, asphyxia, and excitement resuscitate things long since forgotten? If we content ourselves with merely affirming that the faculty of memory is so peculiarly constituted by nature as to exhibit just these oddities, we seem little the better for having invoked it, for our explanation becomes as complicated as that of the crude facts with which we started. Moreover there is something grotesque and irrational in the supposition that the soul is equipped with elementary powers of such an ingeniously intricate sort. Why *should* our memory cling more easily to the near than the remote? Why should it lose its grasp of proper sooner than of abstract names? Such peculiarities seem quite fantastic; and might, for aught we can see *a priori*, be the precise opposites of what they are. Evidently, then, *the faculty does not exist absolutely, but works under conditions; and the quest of the conditions* becomes the psychologist's most interesting task.

However firmly he may hold to the soul and her remembering faculty, he must acknowledge that she never exerts the latter without a *cue*, and that something must always precede and *remind* us of whatever we are to recollect. "An *idea*!" says the associationist, "an idea associated with the remembered thing; and this explains also why things repeatedly met with are more easily recollected, for their associates on the various occasions furnish so many distinct avenues of recall." But this does not explain the effects of fever, exhaustion, hypnotism, old age, and the like. And in general, the pure associationist's account of our mental life is almost as bewildering as that of the pure spiritualist. This multitude of ideas, existing absolutely, yet clinging together, and weaving an endless carpet of themselves, like dominoes in ceaseless change, or the bits of glass in a kaleidoscope, —whence do they get their fantastic laws of clinging, and why do they cling in just the shapes they do?

For this the associationist must introduce the order of experience in the outer world. The dance of the ideas is a copy, somewhat mutilated and altered, of the order of phenomena. But the slightest reflection shows that phenomena have absolutely no power to influence our ideas until they have first impressed our senses and our brain. The bare existence of a past fact is no ground for our remembering it. Unless we have seen it, or somehow *undergone* it, we shall never know of its having been. The experiences of the body are thus one of the conditions of the faculty of memory being what it is. And a very small amount of reflection on facts shows that one part of the body, namely, the brain, is the part whose experiences are directly concerned. If the nervous communication be cut off between the brain and other parts, the experiences of those other parts are non-existent for the mind. The eye is blind, the ear deaf, the hand insensible and motionless. And conversely, if the brain be injured, consciousness

is abolished or altered, even although every other organ in the body be ready to play its normal part. A blow on the head, a sudden subtraction of blood, the pressure of an apoplectic hemorrhage, may have the first effect; whilst a very few ounces of alcohol or grains of opium or hasheesh, or a whiff of chloroform or nitrous oxide gas, are sure to have the second. The delirium of fever, the altered self of insanity, are all due to foreign matters circulating through the brain, or to pathological changes in that organ's substance. The fact that the brain is the one immediate bodily condition of the mental operations is indeed so universally admitted nowadays that I need spend no more time in illustrating it, but will simply postulate it and pass on. The whole remainder of the book will be more or less of a proof that the postulate was correct.

Bodily experiences, therefore, and more particularly brain-experiences, must take a place amongst those conditions of the mental life of which Psychology need take account. *The spiritualist and the associationist must both be 'cerebralists,'* to the extent at least of admitting that certain peculiarities in the way of working of their own favorite principles are explicable only by the fact that the brain laws are a codeterminant of the result.

Our first conclusion, then, is that a certain amount of brain-physiology must be presupposed or included in Psychology[1].

In still another way the psychologist is forced to be something of a nerve-physiologist. Mental phenomena are not only conditioned *a parte ante* by bodily processes; but they lead to them a *parte post*. That they lead to *acts* is of course the most familiar of truths, but I do not merely mean acts in the sense of voluntary and deliberate muscular performances. Mental states occasion also changes in the calibre of blood-vessels, or alteration in the heart-beats, or processes more subtle still, in glands and viscera. If these are taken into account, as well as acts which follow at some *remote period* because the mental state was once there, it will be safe to lay down the general law that *no mental modification ever occurs which is not accompanied or followed by a bodily change*. The ideas and feelings, e. g., which these present printed characters excite in the reader's mind not only occasion movements of his eyes and nascent movements of articulation in him, but will some day make him speak, or take sides in a discussion, or give advice, or choose a book to read, differently from what would have been the case had they never impressed his retina. Our psychology must therefore take account not only of the conditions antecedent to mental states, but of their resultant consequences as well.

But actions originally prompted by conscious intelligence may grow so automatic by dint of habit as to be apparently unconsciously performed. Standing, walking, buttoning and unbuttoning, piano-playing, talking, even saying one's prayers, may be done when the mind is absorbed in other things. The performances of animal *instincts* seem semi-automatic, and the *reflex acts* of self-preservation certainly are so. Yet they resemble intelligent acts in bringing about the *same ends* at which the animals' consciousness, on other occasions, deliberately aims. Shall the study of such machine-like yet purposive acts as these be included in Psychology?

The boundary-line of the mental is certainly vague. It is better not to be pedantic, but to let the science be as vague as its subject, and include such phenomena as these if by so doing we can throw any light on the main business in hand. It will ere long be seen, I trust, that we can; and that we gain much more by a broad than by a narrow

conception of our subject. At a certain stage in the development of every science a degree of vagueness is what best consists with fertility. On the whole, few recent formulas have done more real service of a rough sort in psychology than the Spencerian one that the essence of mental life and of bodily life are one, namely, 'the adjustment of inner to outer relations.' Such a formula is vagueness incarnate; but because it takes into account the fact that minds inhabit environments which act on them and on which they in turn react; because, in short, it takes mind in the midst of all its concrete relations, it is immensely more fertile than the old-fashioned 'rational psychology,' which treated the soul as a detached existent, sufficient unto itself, and assumed to consider only its nature and properties. I shall therefore feel free to make any sallies into zoology or into pure nerve-physiology which may seem instructive for our purposes, but otherwise shall leave those sciences to the physiologists.

Can we state more distinctly still the manner in which the mental life seems to intervene between impressions made from without upon the body, and reactions of the body upon the outer world again? Let us look at a few facts.

If some iron filings be sprinkled on a table and a magnet brought near them, they will fly through the air for a certain distance and stick to its surface. A savage seeing the phenomenon explains it as the result of an attraction or love between the magnet and the filings. But let a card cover the poles of the magnet, and the filings will press forever against its surface without its ever occurring to them to pass around its sides and thus come into more direct contact with the object of their love. Blow bubbles through a tube into the bottom of a pail of water, they will rise to the surface and mingle with the air. Their action may again be poetically interpreted as due to a longing to recombine with the mother-atmosphere above the surface. But if you invert a jar full of water over the pail, they will rise and remain lodged beneath its bottom, shut in from the outer air, although a slight deflection from their course at the outset, or a re-descent towards the rim of the jar when they found their upward course impeded, could easily have set them free.

If now we pass from such actions as these to those of living things, we notice a striking difference. Romeo wants Juliet as the filings want the magnet; and if no obstacles intervene he moves towards her by as straight a line as they. But Romeo and Juliet, if a wall be built between them, do not remain idiotically pressing their faces against its opposite sides like the magnet and the filings with the card. Romeo soon finds a circuitous way, by scaling the wall or otherwise, of touching Juliet's lips directly. With the filings the path is fixed; whether it reaches the end depends on accidents. With the lover it is the end which is fixed, the path may be modified indefinitely.

Suppose a living frog in the position in which we placed our bubbles of air, namely, at the bottom of a jar of water. The want of breath will soon make him also long to rejoin the mother-atmosphere, and he will take the shortest path to his end by swimming straight upwards. But if a jar full of water be inverted over him, he will not, like the bubbles, perpetually press his nose against its unyielding roof, but will restlessly explore the neighborhood until by re-descending again he has discovered a path around its brim to the goal of his desires. Again the fixed end, the varying means!

Such contrasts between living and inanimate performances end by leading men to deny that in the physical world final purposes exist at all. Loves and desires are to-day

no longer imputed to particles of iron or of air. No one supposes now that the end of any activity which they may display is an ideal purpose presiding over the activity from its outset and soliciting or drawing it into being by a sort of *vis a fronte*. The end, on the contrary, is deemed a mere passive result, pushed into being *a tergo*, having had, so to speak, no voice in its own production. Alter the pre-existing conditions, and with inorganic materials you bring forth each time a different apparent end. But with intelligent agents, altering the conditions changes the activity displayed, but not the end reached; for here the idea of the yet unrealized end co-operates with the conditions to determine what the activities shall be.

*The Pursuance of future ends and the choice of means for their attainment are thus the*mark and *criterion of the presence of mentality*in a phenomenon. We all use this test to discriminate between an intelligent and a mechanical performance. We impute no mentality to sticks and stones, because they never seem to move for *the sake of* anything, but always when pushed, and then indifferently and with no sign of choice. So we unhesitatingly call them senseless.

Just so we form our decision upon the deepest of all philosophic problems: Is the Kosmos an expression of intelligence rational in its inward nature, or a brute external fact pure and simple? If we find ourselves, in contemplating it, unable to banish the impression that it is a realm of final purposes, that it exists for the sake of something, we place intelligence at tile heart of it and have a religion. If, on the contrary, in surveying its irremediable flux, we can think of the present only as so much mere mechanical sprouting from the past, occurring with no reference to the future, we are atheists and materialists.

In the lengthy discussions which psychologists have carried on about the amount of intelligence displayed by lower mammals, or the amount of consciousness involved in the functions of the nerve-centres of reptiles, the same test has always been applied: Is the character of the actions such that we must believe them to be performed *for the sake* of their result? The result in question, as we shall hereafter abundantly see, is as a rule a useful one,—the animal is, on the whole, safer under the circumstances for bringing it forth. So far the action has a teleological character; but such mere outward teleology as this might still be the blind result of *vis a tergo*. The growth and movements of plants, the processes of development, digestion, secretion, etc., in animals, supply innumerable instances of performances useful to the individual which may nevertheless be, and by most of us are supposed to be, produced by automatic mechanism. The physiologist does not confidently assert conscious intelligence in the frog's spinal cord until he has shown that the useful result which the nervous machinery brings forth under a given irritation *remains the same when the machinery*is *altered*. If, to take the stock-instance, the right knee of a headless frog be irritated with acid, the right foot will wipe it off. When, however, this foot is amputated, the animal will often raise the *left* foot to the spot and wipe the offending material away.

Pfluger and Lewes reason from such facts in the following way: If the first reaction were the result of mere machinery, they say; if that irritated portion of the skin discharged the right leg as a trigger discharges its own barrel of a shotgun; then amputating the right foot would indeed frustrate the wiping, but would not make the *left*leg move. It would simply result in the right stump moving through the empty air (which is in fact the phenomenon sometimes observed). The right trigger makes no

effort to discharge the left barrel if the right one be unloaded; nor does an electrical machine ever get restless because it can only emit sparks, and not hem pillow-cases like a sewing-machine.

If, on the contrary, the right leg originally moved for the *purpose* of wiping the acid, then nothing is more natural than that, when the easiest means of effecting that purpose prove fruitless, other means should be tried. Every failure must keep the animal in a state of disappointment which will lead to all sorts of new trials and devices; and tranquillity will not ensue till one of these, by a happy stroke, achieves the wished-for end.

In a similar way Goltz ascribes intelligence to the frog's optic lobes and cerebellum. We alluded above to the manner in which a sound frog imprisoned in water will discover an outlet to the atmosphere. Goltz found that frogs deprived of their cerebral hemispheres would often exhibit a like ingenuity. Such a frog, after rising from the bottom and finding his farther upward progress checked by the glass bell which has been inverted over him, will not persist in butting his nose against the obstacle until dead of suffocation, but will often re-descend and emerge from under its rim as if, not a definite mechanical propulsion upwards, but rather a conscious desire to reach the air by hook or crook were the main-spring of his activity. Goltz concluded from this that the hemispheres are not the seat of intellectual power in frogs. He made the same inference from observing that a brainless frog will turn over from his back to his belly when one of his legs is sewed up, although the movements required are then very different from those excited under normal circumstances by the same annoying position. They seem determined, consequently, not merely by the antecedent irritant, but by the final end,—though the irritant of course is what makes the end desired.

Another brilliant German author, Liebmann[2], argues against the brain's mechanism accounting for mental action, by very similar considerations. A machine as such, he says, will bring forth right results when it is in good order, and wrong results if out of repair. But both kinds of result flow with equally fatal necessity from their conditions. We cannot suppose the clock-work whose structure fatally determines it to a certain rate of speed, noticing that this speed is too slow or too fast and vainly trying to correct it. Its conscience, if it have any, should be as good as that of the best chronometer, for both alike obey equally well the same eternal mechanical laws-laws from behind. But if the *brain* be out of order and the man says "Twice four are two," instead of "Twice four are eight," or else "I must go to the coal to buy the wharf," instead of "I must go to the wharf to buy the coal," instantly there arises a consciousness of error. The wrong performance, though it obey the same mechanical law as the right, is nevertheless condemned,—condemned as contradicting the inner law—the law from in front, the purpose or ideal for which the brain *should* act, whether it do so or not.

We need not discuss here whether these writers in drawing their conclusion have done justice to all the premises involved in the cases they treat of. We quote their arguments only to show how they appeal to the principle that *no actions but such as are done for an end, and show a choice of means, can be called indubitable expressions of Mind.*

I shall then adopt this as the criterion by which to circumscribe the subject-matter of this work so far as action enters into it. Many nervous performances will therefore

be unmentioned, as being purely physiological. Nor will the anatomy of the nervous system and organs of sense be described anew. The reader will find in H. N. Martin's *Human Body*, in G. T. Ladd's *Physiological Psychology*, and in all the other standard Anatomies and Physiologies, a mass of information which we must regard as preliminary and take for granted in the present work[3]. Of the functions of the cerebral hemispheres, however, since they directly subserve consciousness, it will be well to give some little account.

Footnotes

[1] Cf. George T. Ladd: *Elements of Physiological Psychology* (1887), pt. III, chap. III, 9, 12

[2] *Zur Analysis der Wirklichkeit*, p. 489

[3] Nothing is easier than to familiarize one's self with the mammalian brain. Get a sheep's head, a small saw, chisel, scalpel and forceps (all three can best be had from a surgical-instrument maker), and unravel its parts either by the aid of a human dissecting book, such as Holden's *Manual of Anatomy*, or by the specific directions *ad hoc* given in such books as Foster and Langley's *Practical Physiology* (Macmillan) or Morrell's *Comparative Anatomy, and Guide to Dissection* (Longman & Co.).

CHAPTER II

The Functions of the Brain

If I begin chopping the foot of a tree, its branches are unmoved by my act, and its leaves murmur as peacefully as ever in the wind. If, on the contrary, I do violence to the foot of a fellow-man, the rest of his body instantly responds to the aggression by movements of alarm or defence. The reason of this difference is that the man has a nervous system whilst the tree has none; and the function of the nervous system is to bring each part into harmonious co-operation with every other. The afferent nerves, when excited by some physical irritant, be this as gross in its mode of operation as a chopping axe or as subtle as the waves of light, conveys the excitement to the nervous centres. The commotion set up in the centres does not stop there, but discharges itself, if at all strong, through the efferent nerves into muscles and glands, exciting movements of the limbs and viscera, or acts of secretion, which vary with the animal, and with the irritant applied. These acts of response have usually the common character of being of service. They ward off the noxious stimulus and support the beneficial one; whilst if, in itself indifferent, the stimulus be a sign of some distant circumstance of practical importance, the animal's acts are addressed to this circumstance so as to avoid its perils or secure its benefits, as the case may be. To take a common example, if I hear the conductor calling 'All aboard!' as I enter the depot, my heart first stops, then palpitates, and my legs respond to the air-waves falling on my tympanum by quickening their movements. If I stumble as I run, the sensation of falling provokes a movement of the hands towards the direction of the fall, the effect of which is to shield the body from too sudden a shock. If a cinder enter my eye, its lids close forcibly and a copious flow of tears tends to wash it out.

These three responses to a sensational stimulus differ, however, in many respects. The closure of the eye and the lachrymation are quite involuntary, and so is the disturbance of the heart. Such involuntary responses we know as 'reflex' acts. The motion of the arms to break the shock of falling may also be called reflex, since it occurs too quickly to be deliberately intended. Whether it be instinctive or whether it result from the pedestrian education of childhood may be doubtful; it is, at any rate, less automatic than the previous acts, for a man might by conscious effort learn to perform it more skilfully, or even to suppress it altogether. Actions of this kind, into which instinct and volition enter upon equal terms, have been called 'semi-reflex.' The act of running towards the train, on the other hand, has no instinctive element about it. It is purely the result of education, and is preceded by a consciousness of the purpose to be attained and a distinct mandate of the will. It is a 'voluntary act.' Thus the animal's reflex and voluntary performances shade into each other gradually, being connected by acts which may often occur automatically, but may also be modified by

conscious intelligence.

An outside observer, unable to perceive the accompanying consciousness, might be wholly at a loss to discriminate between the automatic acts and those which volition escorted. But if the criterion of mind's existence be the choice of the proper means for the attainment of a supposed end, all the acts seem to be inspired by intelligence, for *appropriateness* characterizes them all alike. This fact, now, has led to two quite opposite theories about the relation to consciousness of the nervous functions. Some authors, finding that the higher voluntary ones seem to require the guidance of feeling, conclude that over the lowest reflexes some such feeling also presides, though it may be a feeling of which *we* remain unconscious. Others, finding that reflex and semi-automatic acts may, notwithstanding their appropriateness, take place with an unconsciousness apparently complete, fly to the opposite extreme and maintain that the appropriateness even of voluntary actions owes nothing to the fact that consciousness attends them. They are, according to these writers, results of physiological mechanism pure and simple. In a near chapter we shall return to this controversy again. Let us now look a little more closely at the brain and at the ways in which its states may be supposed to condition those of the mind.

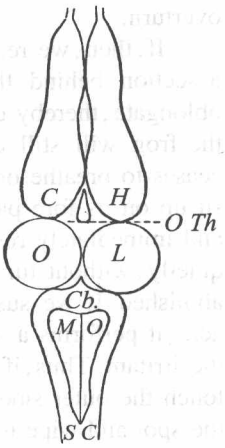

FIG. 1—*C H*, Cerebral Hemispheres; *O Th*, optic Thalami; *O L*, Optic Lobes; *Cb*, Cerebellum; *M O*, Medulla Oblongata; *S C*, Spinal Cord.

THE FROG'S NERVE-CENTRES

Both the minute anatomy and the detailed physiology of the brain are achievements of the present generation, or rather we may say (beginning with Meynert) of the past twenty years. Many points are still obscure and subject to controversy; but a general way of conceiving the organ has been reached on all hands which in its main feature seems not unlikely to stand, and which even gives a most plausible scheme of the way in which cerebral and mental operations go hand in hand.

The best way to enter the subject will be to take a lower creature, like a frog, and study by the vivisectional method the functions of his different nerve-centres. The frog's nerve-centres are figured in the accompanying diagram, which needs no further explanation. I will first proceed to state what happens when various amounts of the anterior parts are removed, in different frogs, in the way in which an ordinary student removes them; that is, with no extreme precautions as to the purity of the operation. We shall in this way reach a very simple conception of the functions of the various centres, involving the strongest possible contrast between the cerebral hemispheres and the lower lobes. This sharp conception will have didactic advantages, for it is often very instructive to start with too simple a formula and correct it later on. Our first formula, as we shall later see, will have to be softened down somewhat by the results of more careful experimentation both on frogs and birds, and by those of the most recent observations on dogs, monkeys, and man. But it will put us, from the outset, in clear possession of some fundamental notions and distinctions which we could otherwise not gain so well, and none of which the later more completed view will

overturn.

If, then, we reduce the frog's nervous system to the spinal cord alone, by making a section behind the base of the skull, between the spinal cord and the medulla oblongata, thereby cutting off the brain from all connection with the rest of the body, the frog will still continue to live, but with a very peculiarly modified activity. It ceases to breathe or swallow; it lies flat on its belly, and does not, like a normal frog, sit up on its fore paws, though its hind legs are kept, as usual, folded against its body and immediately resume this position if drawn out. If thrown on its back, it lies there quietly, without turning over like a normal frog. Locomotion and voice seem entirely abolished. If we suspend it by the nose, and irritate different portions of its skin by acid, it performs a set of remarkable 'defensive' movements calculated to wipe away the irritant. Thus, if the breast be touched, both fore paws will rub it vigorously; if we touch the outer side of the elbow, the hind foot of the same side will rise directly to the spot and wipe it. The back of the foot will rub the knee if that be attacked, whilst if the foot be cut away, the stump will make ineffectual movements, and then, in many frogs, a pause will come, as if for deliberation, succeeded by a rapid passage of the opposite unmutilated foot to the acidulated spot.

The most striking character of all these movements, after their teleological appropriateness, is their precision. They vary, in sensitive frogs and with a proper amount of irritation, so little as almost to resemble in their machine-like regularity the performances of a jumping-jack, whose legs must twitch whenever you pull the string. The spinal cord of the frog thus contains arrangements of cells and fibres fitted to convert skin irritations into movements of defence. We may call it the *centre for defensive movements* in this animal. We may indeed go farther than this, and by cutting the spinal cord in various places find that its separate segments are independent mechanisms, for appropriate activities of the head and of the arms and legs respectively. The segment governing the arms is especially active, in male frogs, in the breeding season; and these members alone with the breast and back appertaining to them, everything else being cut away, will then actively grasp a finger placed between them and remain hanging to it for a considerable time.

The spinal cord in other animals has analogous powers. Even in man it makes movements of defence. Paraplegics draw up their legs when tickled; and Robin, on tickling the breast of a criminal an hour after decapitation, saw the arm and hand move towards the spot. Of the lower functions of the mammalian cord, studied so ably by Goltz and others, this is not the place to speak.

If, in a second animal, the cut be made just behind the optic lobes so that the cerebellum and medulla oblongata remain attached to the cord, then swallowing, breathing, crawling, and a rather enfeebled jumping and swimming are added to the movements previously observed.[1] There are other reflexes too. The animal, thrown on his back, immediately turns over to his belly. Placed in a shallow bowl, which is floated on water and made to rotate, he responds to the rotation by first turning his head and then waltzing around with his entire body, in the opposite direction to the whirling of the bowl. If his support be tilted so that his head points downwards, he points it up; he points it down if it be pointed upwards, to the right if it be pointed to the left, etc. But his reactions do not go farther than these movements of the head. He will not, like frogs whose thalami are preserved, climb up a board if the latter be

tilted, but will slide off it to the ground.

If the cut be made on another frog between the thalami and the optic lobes, the locomotion both on land and water becomes quite normal, and, in addition to the reflexes already shown by the lower centres, he croaks regularly whenever he is pinched under the arms. He compensates rotations, etc., by movements of the head, and turns over from his back; but still drops off his tilted board. As his optic nerves are destroyed by the usual operation, it is impossible to say whether he will avoid obstacles placed in his path.

When, finally, a frog's cerebral hemispheres alone are cut off by a section between them and the thalami which preserves the latter, an unpractised observer would not at first suspect anything abnormal about the animal. Not only is he capable, on proper instigation, of all the acts already described, but he guides himself by sight, so that if an obstacle be set up between him and the light, and he be forced to move forward, he either jumps over it or swerves to one side. He manifests sexual passion at the proper season, and, unlike an altogether brainless frog, which embraces anything placed between his arms, postpones this reflex act until a female of his own species is provided. Thus far, as aforesaid, a person unfamiliar with frogs might not suspect a mutilation; but even such a person would soon remark the almost entire absence of spontaneous motion—that is, motion unprovoked by any *present* incitation of sense. The continued movements of swimming, performed by the creature in the water, seem to be the fatal result of the contact of that fluid with its skin. They cease when a stick, for example, touches his hands. This is a sensible irritant towards which the feet are automatically drawn by reflex action, and on which the animal remains sitting. He manifests no hunger, and will suffer a fly to crawl over his nose unsnapped at. Fear, too, seems to have deserted him. In a word, he is an extremely complex machine whose actions, so far as they go, tend to self-preservation ; but still a *machine*, in this sense—that it seems to contain no incalculable element. By applying the right sensory stimulus to him we are almost as certain of getting a fixed response as an organist is of hearing a certain tone when he pulls out a certain stop.

But now if to the lower centres we add the cerebral hemispheres, or if, in other words, we make an intact animal the subject of our observations, all this is changed. In addition to the previous responses to present incitements of sense, our frog now goes through long and complex acts of locomotion *spontaneously*, or as if moved by what in ourselves we should call an idea. His reactions to outward stimuli vary their form, too. Instead of making simple defensive movements with his hind legs like a headless frog if touched, or of giving one or two leaps and then sitting still like a hemisphereless one, he makes persistent and varied efforts at escape, as if, not the mere contact of the physiologist's hand, but the notion of danger suggested by it were now his spur. Led by the feeling of hunger, too, he goes in search of insects, fish, or smaller frogs, and varies his procedure with each species of victim. The physiologist cannot by manipulating him elicit croaking, crawling up a board, swimming or stopping, at will. His conduct has become incalculable. We can no longer foretell it exactly. Effort to escape is his dominant reaction, but he *may* do anything else, even swell up and become perfectly passive in our hands.

Such are the phenomena commonly observed, and such the impressions which one naturally receives. Certain general conclusions follow irresistibly. First of all the