

THE PSYCHOLOGICAL REVIEW.

PSYCHOLOGY AND PHYSIOLOGY.¹

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In a paper which I read two years ago before this Association, I endeavored to make clear the nature of the work done by the psychologist, and to set forth the assumptions upon which he must proceed and the method he must employ. I maintained that he must assume the existence of an external physical world, and the existence of certain copies or representatives of it intimately related to particular bodily organisms. These transcripts of the external world, supplemented by certain elements not supposed to have their prototypes without (feelings of pleasure and pain, etc.) are called minds. I stated that it was the task of the psychologist, with the aid of introspection, observation and experiment, to obtain a knowledge of such minds, and to reduce their phenomena to laws. I held further that, whether we regard mental phenomena as parallel with nervous processes, or as belonging to the same series with them and forming a part of the one chain, that does not affect the fundamental assumption of the psychologist, the assumption of an external world and of minds which mirror it, nor does it affect his general method of procedure, the employment of introspection, observation and experiment.

These positions seem to me to be commonplaces of psychology, and so generally accepted, explicitly or implicitly, that they may be taken without question. They appear also to de-

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fine with some exactness the field which belongs to the psychologist, and to make possible a line of demarkation between psychology and other scientific disciplines. As, however, the sciences differentiate themselves clearly from one another, and acquire definiteness, only as they approach a high state of development, and as psychology and the sciences which lie nearest to it must be admitted to be still in their infancy, it is not to be wondered at that the question of boundaries should often be mooted, and charges and countercharges of trespass made with some warrant. It was but lately that psychology was scarcely recognized as a separate science at all, being treated as a branch of philosophy, and psychological facts being served in a sauce of epistemological speculations. From this condition of affairs the science is gradually emerging. The separation is by no means complete in fact, as a glance at many of our psychologies will show, but we may console ourselves with the thought that the state of affairs is better than it was, and that human knowledge is gaining through the change.

In our own day the living question is that of the relation of psychology to physiology, and of the line of demarkation between them. We hear charges that the psychologists sometimes occupy themselves in doing work which is purely physiological, and one who reads the text-books of physiology cannot but see that the writer is frequently on ground not properly his own. Where are we to draw the line between the two fields? And if a clear line can be drawn, how far is it desirable that a division of labor should take place? It is to a brief discussion of these questions that this paper is devoted.

I have said above that whether we regard mental phenomena as parallel with nervous processes, or as belonging to the same series with them and in causal relation with the world of things, it need not affect our view of the fundamental assumptions of psychology or of psychological method. But in discussing the line of demarkation between psychology and physiology, this question of the nature of the relation between mind and body may become an important one, and it will be convenient to treat my subject under two heads; that is, to inquire into the relations of these sciences on the assumption that mental states and bodily

do not belong to the same series, but are merely parallel (the so-called automaton theory) ; and then to consider the effect of regarding the two sets of phenomena as forming one causally related whole.

I.

Assuming, then, that mental states have no influence upon bodily, and that the so-called sensory-motor arc consists of an unbroken chain of physical processes, what are the limits of the science of physiology? The task of the physiologist lies in the study of the functioning of living bodies. These bodies form a part of the physical world, a world complete in itself, and which demands for none of its phenomena an explanation drawn from any other sphere. To explain physical actions, however complicated, the physiologist should have recourse to bodily processes, which in turn find their explanation in other physical processes, and these in still others, and so on without end. The rhythmic contraction of a heart, the fall of an eyelid stimulated by an irritation of the conjunctiva, the unconscious gnawing at a fingernail, and the intricate chain of actions which result in the production of a work of art or a scientific treatise, all must be explained in the same way, as one explains the unfolding of a leaf or the reddening of an apple. In each case we have the functioning of a living body, a physical thing, and our causes and effects must all be physical.

This complete physical explanation of the functioning of organisms is, of course, only an ideal, and an ideal which, in the present condition of the science of physiology, smiles at us from a hopeless distance. Whether it be the contraction of a heart, or the fall of an eye-lid, or the biting of a finger-nail, or the penning of a sentence, the chain of physical causes which bring about these results lies hidden in that darkness which encloses the glimmering taper of our science. Exact knowledge of the antecedents of any bodily movement does not exist, and in its absence the physiologist is forced to give such fragmentary explanations as he can, often even overstepping the limits of his own science and using conceptions which are really out of place in it, but which he seems to be compelled to use *faute*

de mieux. He has no right to speak of sensations, of feelings, of ideas; they are not in his world. The functioning of a brain, as he is concerned with it, results in motions immediate or remote, not in feelings and thoughts; and to make use of such in his reasonings amounts to confessing, either that he chooses to be a psychologist as well as a physiologist, or that, having found his own road impassable, he has been forced to continue his journey upon that of his neighbor.

How little the physiologist is in a position to furnish such an explanation of the functioning of organisms as I have outlined above is impressed upon one who reads critically our standard text-books upon physiology. One sees that, if we eliminate from the chapters which treat of the nervous system the anatomical portions and the psychological portions, the residue is surprisingly small. Certainly nowhere do we find such a description of the antecedents of a bodily movement as I have held up as our ideal. Let me take for illustration the well known work by Professor Foster, which is so widely used as a text-book. The learning and candor of the author, as well as his caution in the expression of opinions, make him, I think, a desirable representative of his class. I shall quote a few passages from various parts of his book.¹

The necessary limits of such a paper as this force me to omit much that directly bears upon the subject under discussion. The question is as to the exact chain of physiological events between a sensory stimulus and the resultant muscular movements. We have to consider the occurrences in the nerves and in the nervous centres, both spinal and cerebral. As Dr. Foster begins with the motor processes, I shall consider these first.

As to the changes in a nerve during the passage of the nervous impulse our author is frank in his admission of ignorance. He regards it as clear that the impulse is something quite dif-

¹ I shall quote from the sixth London edition. That the book may stand as a representative of its class becomes clear when one examines almost any of the more recent works on the subject; *e. g.*, Waller's 'Introduction to Human Physiology, (London, 1893); Bernstein's 'Lehrbuch der Physiologie' (Stuttgart, 1894); Munk's 'Physiologie des Menschen und der Säugethiere' (Berlin, 1892); or the 'Vergleichende Physiologie der Haussäugethiere', edited by Ellenberger (Berlin, 1892).

ferent from the ordinary electric current, but what it is he does not venture to say (Part I, pp. 127, 156).

The mechanisms with which the spinal cord is provided appear also to be mere matter of conjecture. Concerning these mechanisms Dr. Foster speaks as follows: "If we regard the spinal cord, and apparently we have a right to do so, as resulting from the fusion of a series of segments or metameres, each segment, represented by a pair of spinal nerves, being a ganglionic mass, that is to say, a mass containing nerve cells with which nerve fibres are connected, we should expect to find that the fibres of a spinal nerve soon after entering in, or before issuing from the spinal cord, are connected with nerve cells lying in the neighborhood of the attachment of the nerve to the cord. We should, we say, expect to find this; but owing to the difficulty of tracing individual nerve fibres through the tangled mass of the substance of the cord, our actual knowledge of the termination of the fibres of the posterior root, and origin of the fibres of the anterior root, is at present far from complete" (III, 876). In a later section we come upon this passage: "From these and similar phenomena we may infer that the nervous network spoken of above¹ is, so to speak, mapped out into nervous mechanisms by the establishment of lines of greater or less resistance, so that the disturbances in it generated by certain afferent impulses are directed into certain efferent channels. It may be added that though conspicuously purposeful movements seem to need the concurrent action of several segments of the cord, and as a rule the greater the length of the cord involved, the more complex and the more distinctly purposeful the movement, still the movements evoked by even a segment of the cord may be purposeful in character; hence we must conclude that every segment of the nervous network is mapped out into mechanisms" (III., 909). A little further we find: "But if the spinal cord possesses mechanisms for carrying out coördinated movements, which in the case of voluntary movements are discharged by nervous impulses descending from the brain, we may infer that in reflex actions the same me-

¹ *i. e.*, The grey matter of the cord.

chanisms are brought into action, though they are discharged by afferent impulses coming along afferent nerves instead of by impulses descending from the brain. The movements of reflex origin, in all their features, except their exciting cause, appear identical with voluntary movements; the two can only be distinguished from each other by a knowledge of the exciting cause. And it seems unreasonable to suppose that the spinal cord should possess two sets of mechanisms in all respects identical, save that the one is discharged by volitional impulses from the brain and the other by afferent impulses from afferent nerves" (III., 910).

We are then, it seems, forced to assume the existence in the cord of various mechanisms for carrying out movements. What these mechanisms are and how they act we do not know. We know only that *something* happens in the cord, not *what* happens.

Our ignorance regarding the structure and functions of the bulb appears to be also great. I shall cite but two extracts: "Thus of the various tracts or strands of the spinal cord two only are known definitely and certainly to pass as conspicuous unbroken strands through the bulb to or from higher parts; namely, the pyramidal tract to the cerebrum and the cerebellar tract to the cerebellum; all or nearly all the rest of the longitudinal fibres of the cord reaching the bulb end, as far as we know at present, in some part or other of the bulb; and we may infer that some or other nerve cells of the bulb serve as relays to connect these fibres of the cord with other parts of the brain" (III., 949). "Meanwhile enough has been said to show that the bulb differs very materially in structure from the spinal cord. The grey matter of the bulb is far more complex in its nature than is that of any part of the cord; and the arrangement of the several strands and tracts of fibres is far more intricate. The structural features on the whole, perhaps, suggest that the main functions of the bulb are two-fold; on the one hand, it seems fitted to serve as a head centre governing the spinal cord, the various reins of which, with the exceptions noted, it holds, as it were, in its hands; on the other hand, it appears no less adapted to act as a middleman between parts of the spinal cord below

and various regions of the brain above. As we shall see, experiment and observation give support to these suggestions" (951). It is scarcely necessary for me to add that the experiment and observation referred to do not remove the questions as to the functions of the bulb and the mechanisms it contains from the field of conjecture.

The section entitled "The Disposition and Connections of the Grey and White Matter of the Brain" opens with the following passage: "As we pass up from the bulb to the higher parts of the brain, the differentiation of the grey matter into more or less separate masses, which we have seen begin in the bulb, becomes still more striking. We have to distinguish a large number of areas or collections of grey matter more or less regular in form and more or less sharply defined from the surrounding white matter; to such collections the several terms *corpus*, *locus*, *nucleus* and the like have from time to time been given. These areas or collections vary greatly in size, in form and in histological characters; they differ from each other in the form, size, features and arrangement of the nerve cells, in the characters of the nervous network of which the nerve cells form a part, and especially perhaps in the extent to which the more distinctly grey matter is traversed and broken up by bundles of white fibres. Guided by the analogy of the spinal cord, as well as by the results of experiments and observations directed to the brain itself, we are led to believe that the complex functions of the brain are intimately associated with this grey matter; and a full knowledge of the working of the brain will carry with it a knowledge of the nature and meaning of the intricate arrangement of the cerebral grey matter. At present, however, our ignorance as to these things is great; and, though various theoretical classifications of the several collections of grey matter have been proposed, it will perhaps be wisest to content ourselves here with a very broad and simple arrangement" (III., 952).

This modest exordium is followed by a number of frank confessions of ignorance which appear fully to justify it. We find such statements as: "Our knowledge of the finer histological details of the various masses of grey matter is at present too

imperfect to afford any basis whatever for physiological deductions, and it will be hardly profitable to dwell upon them" (1022). "In the present state of knowledge it is impossible to come to any satisfactory conclusion concerning the meaning of the variety and arrangement of the cells and other constituents of the cortex" (1032). These two citations are of a sufficiently sweeping character to cover the whole ground; I shall, however, allow myself the space necessary to present two somewhat more lengthy extracts. They are as follows: "In the spinal cord we were able to divide all the fibres into afferent and efferent respectively, though even here we meet with some difficulty. Dealing with the cerebral cortex, which, as we have already seen, is certainly especially concerned in voluntary movements and in the development of full sensations, we may be tempted to consider the fibres connected with the grey matter similarly divisible into motor and sensory; and we may go on to suppose that the fibres joining the cortex as axis cylinder processes of recognizable cells are motor fibres, and that all the other fibres joining the grey matter in some way are sensory fibres. But in doing so we are going beyond our tether; in all probability the nervous processes going on in the cortex are far too complex to permit such a simple classification of the functions of fibres as that into motor and sensory; and any attempt to arrange either fibres or regions of the cortex as simply motor or sensory is probably misleading" (1033). "The exact nature of the part played by the cortex and the pyramidal tract in voluntary movements our present knowledge is inadequate to define. When we pass in review a series of brains from the lower to the higher and see how the pyramidal system is, so to speak, grafted on to the rest of the brain, when we observe how the increasing differentiation of the motor cortex runs parallel to the increasing possession of skilled educated movements, we may perhaps suppose that 'a short cut' from the cortex to the origins of the several motor nerves, such as is afforded by the pyramidal fibres, from the advantages it offers to the more primitive path from segment to segment along the cerebro-spinal axis, has by natural selection been developed into being in man the chief and most important instrument for carrying out volun-

tary movements; but, we repeat, it remains even in its highest development a link in a chain, and a knowledge of how the whole chain works is at present hidden from us" (1063).

So much for the nervous antecedents of movements. The few extracts I have given justify, I think, my statement that the physiologist is not in a position to give any accurate account of the chain of causes which led to the fall of an eyelid or the penning of a sentence. What happens in the brain is unknown; what happens in the lower centres is also unknown; the nature of the nervous impulse is still problematic. It is not for the psychologist to throw stones, and I lay emphasis upon this ignorance on the part of our fellow-workers in science only because it seems to me an important source of confusion as to the limits of the science of physiology. Sciences grow in definiteness as they develop, and the lines which mark them out from one another become more distinct. Here we are dealing with something very vague and very dim, and one may expect a body of knowledge so dim and vague to have a misty and uncertain boundary.

Our author expresses in various places a desire to remain on purely physiological ground and to avoid a mixture of psychology in his discussions. He puts forward a few cautious statements which would rather incline one to believe that he sympathizes with the view of the relation of nervous processes to mental phenomena assumed to be true in this part of my paper. "Looking at the matter," he says, "from a purely physiological point of view (the only one which has a right to be employed in these pages), the real difference between an automatic act and a voluntary act is that the chain of physiological events between the act and its physiological cause is in the one case short and simple, in the other long and complex" (III., 1004). A little further we find the same thought: "In short, the more we study the phenomena exhibited by animals possessing a part only of their brain, the closer we are pushed to the conclusion that no sharp line can be drawn between volition and the lack of volition, or between the possession and absence of intelligence. Between the muscle-nerve preparation at the one limit, and our conscious willing selves at the other, there is a continuous grada-

tion without a break ; we cannot fix on any linear barrier in the brain or in the general nervous system, and say, 'beyond this there is volition and intelligence, but up to this there is none' " (III., 1007). And at the close of the discussion of voluntary movements we come upon still another striking passage : "Lastly, without attempting to enter into psychological questions, we may at least say that the birthplace of what we call the 'will' is not conterminous with the motor area ; the will arises from a complex series of events, some of which take place in other regions of the cortex, and probably in other parts of the brain as well. With these parts the motor area has ties concerned not in the carrying out of volition, but in the generation of the will. So that, looking round on all sides, it is obvious, as we have said, that the motor area is a mere link in a complex chain " (III., 1069).

These passages are, to be sure, capable of more than one interpretation, and I shall again refer to them later ; but it is at least clear from them and from others that the author has desired to avoid unnecessary trespass on psychological ground. That he constantly make use, however, of psychological conceptions the most cursory examination of his book makes evident. We read that a common effect of the arrival at the central nervous system of impulses passing along afferent nerves is a change in consciousness, or a sensation (III., 850, 851) ; that the effects of 'shock' may be a temporary diminution or loss of consciousness, of volition, of reflex movements and other nervous actions (903) ; that a muscle may be thrown into contraction by the will (906) ; that choice may be determined in some cases by an intelligence (909) ; that mechanisms in the lumbar cord may be brought into play by the will (914) ; that, in the case of a frog deprived of its whole brain, the signs of the working of an intelligent volition are either wholly absent or extremely rare (999) ; that the operations of the will are limited by the machinery at its command (1002) ; that we may, perhaps, speak of a mutilated animal as the subject of sensations, but that there is no satisfactory evidence that it possesses either visual or other perceptions, or that the sensations which it experiences give rise to ideas (1006) ; that in an ordinary voluntary movement

an intelligent consciousness is an essential element (1068), and that the will, blundering at first in the maze of the nervous network, gradually establishes easy paths (1069).

These statements from one who declares that in his pages things must be looked at from a purely physiological point of view, and who realizes that the science of psychology occupies a distinct field upon which it is not desirable that he should encroach, are very suggestive. May we not assume that they find their explanation in the fact that poverty of physiological data forces the physiologist off his own ground? A physiologist, like everyone else, is conscious that he experiences sensations, has perceptions, reflects and wills. What actions of the brain correspond to these physiological facts? Dr. Foster has frankly admitted that he does not know. Yet we must assume that there are nervous occurrences which thus correspond, and it is desirable to mark distinctions between these hypothetical occurrences. How mark these distinctions? There appears to be no other way to do it than to abandon physiology and turn to psychology. It ought, however, in the interests of clear thinking, to be distinctly recognized that this is a makeshift, and argues that the science which must thus be pieced out by scraps taken from another one is in a very imperfect state of development. Such a makeshift ought not to be allowed to obliterate the line dividing the two sciences thus forcibly brought together.

If the parts of Dr. Foster's treatise concerned with the motor aspects of the nervous system have seemed to wander from the field of pure physiology, the parts concerned with its sensory aspects must be regarded as sinning in a still higher degree. The discussion opens with a section entitled "On the Development within the Central Nervous System of Visual and of some other Sensations," and this is followed by one entitled "On the Development of Cutaneous and some other Sensations."

To the thoughtful reader of his pages the author's reasons for selecting these psychological titles seems clear. We are informed that "in dealing with sensory effects we must expect and be content for the present with conclusions less definite and more uncertain even than those gained by the study of motor

effects" (III., 1077). We find that, speaking of the functioning of the cortex in vision, "the only clear and consistent statement which can be made with any confidence is the broad and simple one that the hind region of the cortex is in some way intimately concerned in vision" (III., 1083); and that "although the matter is thus in many of its details at present outside our exact knowledge, we may probably conclude that in the complex act of complete vision, while part, especially the more psychological part, is carried out in the cortex, more particularly of the occipital region, part is accomplished in the lower centres, the tegmental masses. As to the several functions of the three masses,¹ we know almost absolutely nothing" (1084). We learn that the olfactory nerve "is undoubtedly the nerve of smell" (1085), and that, "though the evidence on the whole goes to show that the cortex at the front end of the hippocampal gyrus is especially connected with smell * * * yet the whole matter stands on a somewhat different footing from the sense of sight" (1087). We learn further that "though sensations of taste enter largely into the life of animals, and indeed of man himself, we have no satisfactory indications which will enable us to connect this special sense with any part of the cortex" (1088). We are told that "the connections of the auditory nerve with the cerebral hemisphere belong to the same category as those of other afferent cranial, and, we may add, spinal, nerves; we have no very clear anatomical guide toward any particular part of the cortex" (1088); and that though the method of degeneration suggests a connection with the cortex of the temporal lobe, "the matter needs further investigation" (1089). As to cutaneous and other sensations arising through impulses along the nerves of the body generally, our author speaks as follows: "The fairly convincing evidence that the occipital cortex has special relations with vision, and the less clear evidence that other regions have special relations with smell and hearing, suggest that special parts of the cortex have special relations with the sensations now under consideration. But in the cases of the senses of sight and smell we had a distinct anatomical

¹ *i. e.*, The lateral corpus geniculatum, the pulvinar, and the anterior corpus quadrigeminum.

leading ; and we have seen how uncertain is the evidence where such an anatomical leading fails, as in hearing and taste. In the case of sensations of the body at large, the anatomical leading similarly fails" (1091).

In view of the above statements we cannot regard it as surprising that the author comes to the conclusion that "it is difficult to say anything definite concerning the transmission of sensory impulses and the development of sensations" (III., 1109). Neither is it surprising that he has chosen psychological titles for his discussions. The only thing which appears to be known with sufficient definiteness to be named appears to be the sensation. The corresponding nervous process is covered with thick darkness—darkness which may be felt. And it is not surprising that in a section of his work with the unexceptionable physiological title, 'On the Time Taken up by Cerebral Operations,' we should find the following odd mixture of physiology and psychology : "The events taking place in the central stage are of course complex, and this stage may be subdivided into several stages. Without attempting to enter into psychological questions, we may at least recognize certain elementary distinctions. The afferent impulses started by the stimulus, whatever be their nature, when they reach the central nervous system undergo changes, and, as we have seen, probably complex changes, before they become sensations ; and further changes, now of a more distinctly psychical character, are necessary before the mind can duly appreciate the characters of these sensations and act accordingly. Then come the psychical processes through which these appreciated sensations, or perceptions, or apperceptions, as they are sometimes called, determine an act of volition. Lastly, there are the executive processes of volition, the processes which, physical to begin with, end in the issue of coördinate motor impulses, or, in other words, start the distinctly physiological processes of the efferent stage. We may thus speak of the time required for the perception of the stimulation, of the time required for the action of the will, and of the time required for the complex psychical processes which link these two together" (III., 1122). We may admit that the author has not attempted to enter into psychological

questions; we may even admit that he has attempted to keep out of them; but surely he has wandered on to ground which the most liberal use of language would not permit us to call physiological; and we cannot help raising the question whether what is not psychological is to be distinguished from what is simply by the fact that it is briefly and superficially treated. Sensations, perceptions, apperceptions, volition—are not these the things with which psychology deals?

In his chapters on the senses (IV., pp. 1-305) Dr. Foster appears to have forgotten that he has resolved to avoid psychological questions. These chapters cover some three hundred pages, and may, I think, be fairly described as a treatise on the peripheral sense organs, with rather full psychological appendices. The eye is discussed at length, and from that one passes to visual sensations, visual perceptions and visual judgments. What happens between the retina and the 'hind part of the cortex,' and what happens in that region of the cortex, are passed over in silence. The reason for these omissions the previous section on the development of sensations within the central nervous system makes clear. What happens between the retina and the cortex is not known. The chapter on sight is accordingly necessarily restricted to a discussion of the eye and of the psychology of vision. In the next chapter we similarly pass from a study of the ear to auditory sensations, perceptions and judgments. In the chapter following that, we find a section on the olfactory mucous membrane followed by one on olfactory sensations; and one on the peripheral organs of taste followed by one on gustatory sensations. The chapter on 'Cutaneous and Some Other Sensations' resembles those which precede it. There is some discussion of peripheral organs and much psychological material. It seems evident to the thoughtful reader of Dr. Foster's pages that he is everywhere forced out of his field by poverty of established physiological data. He travels on a parallel road because he finds his own impassable.

In the preceding I have confined myself to the examination of a single work on physiology. I have done so for convenience. The work is fairly representative of its class, and

I might have chosen in its place any one of a considerable number. The results of the examination appear to me to make it evident that we are as yet very far indeed from having realized the ideal set for the physiologist in the explanation of bodily movements. They appear also to make it evident that the physiologist is much given to trespassing on psychological ground. Far be it from me to imply that physiologists have no right to do psychological work, or that some of them may not do certain kinds of such work better than many psychologists. I do not even mean to maintain that, in the existing state of the science of physiology, it may not be wise for the physiologist to occasionally trespass in the interests of his own proper work. On this point I shall speak further in a few moments. What I wish to emphasize now is this: a completed science of physiology would, on the hypothesis which serves as a basis to this part of my paper, be wholly independent of psychology, and a book on physiology would have no excuse for containing psychology. As it is, such books contain a great deal of psychological material; and it should not be overlooked that this is psychological, and that, in dealing with it, the usual psychological method must be followed. It should never be assumed that, because it is found in works professedly concerned with another science, it is anything more than a 'quatorzième,' invited, nay, compelled to come in, to fill an unwelcome gap. Its presence in physiological discussions should not be allowed to obscure the line dividing two sciences, each of which has its appropriate method of investigation.

II.

In what precedes I have rested upon the assumption that bodily states and mental are not causally related in the strict sense of the words—that the two series are, so to speak, parallel. In other words I have assumed the truth of the so-called 'automaton' theory. It is to be noted, however, that, whatever may be the opinion of the physiologist on this point, his language does not favor such a view of the relation of mind and body. One who repudiates the theory—and I think it is a bold man who will dare to maintain that the present state of our knowledge

justifies us in holding that the theory is proved to be true and must necessarily be accepted—one who repudiates the theory may view the relation between mind and body in either of two other ways. He may regard mental states as belonging to the physical series in the sense that they are effects of physical causes, and in their turn causes of physical effects; or he may regard the mind as a something at least partially independent of the physical series, and, as it were, breaking in upon it.

In either case the chain of purely physical events between the peripheral stimulus and the resultant movement is broken by the interpolation of something of a different kind. The sensory-motor arc is partly physical and partly psychical. How does this effect our views as to the relations of the two sciences, physiology and psychology?

The former of these two ways of viewing the relation between mind and body is, I think, most in harmony with the language used by physiologists generally. Certainly, it is most in harmony with that used by Dr. Foster, as the extracts already given sufficiently indicate. Even the passages which, as I said above, might be taken as indicating that Dr. Foster favored the 'automaton' theory, may perhaps be understood as supporting this doctrine. The afferent impulses started by a physical stimulus are supposed, when they reach the central nervous system, to become sensations; the will is said to arise from a complex series of events which take place in various regions of the cortex and probably in other parts of the brain as well; and we are told that mechanisms in the lumbar cord may be brought into play by the will. Here we have, if we take the author's words as they stand, a composite arc—physical, psychical, and physical.

I am not inclined, however, to take such statements too seriously. Physiologists do not appear to pick their words very carefully, nor do they appear to have given much serious thought to this question of the relation of mind and body. It would be obviously unfair to read into their statements more than they have themselves seen in them. Nevertheless, it is worthy of mention that, even if their language is chosen only for convenience and is meant to be interpreted loosely, it is

clearly misleading in case they do not hold to the view I am discussing; and it would be much better did they exercise a little care in expression. If, on the other hand, looseness of expression is an indication of looseness and vagueness of thought, it is highly desirable that it be vigorously attacked and speedily brought to an end.

But whatever be the real opinion of the physiologist regarding the matter, it remains to discuss this view of the relation of mind and body. If we accept it we have, it is true, from initial stimulus to resulting movement, but the one causal series. It is, however, a series made up of two quite different kinds of elements. We have, on the one hand, physical changes which may be studied, as are all physical changes, by directly objective methods. We now know very little about the changes in a nerve during the passage of the nervous impulse, but there is no reason to think that we may not justly expect to investigate these changes by the same methods as those employed in the investigation of physical and chemical problems. On the other hand, we have also to reckon with psychical facts, sensations, perceptions, volitions; and in whatever series one may be inclined to place these, it seems incredible that one should expect to study them just as one would study the changes in a muscle during contraction. It is not inconceivable that with improved apparatus we may some day arrive at an ocular demonstration of the translocation of molecules there supposed to take place. But would the most ardent physiologist expect an exhaustive study of the brain to reveal directly sensations of color or sound, or feelings of pleasure or pain? I am not now speaking of molecular changes corresponding to such psychical facts, but of the facts themselves. Surely there is but one way of reaching such facts, and that is by the use of introspection; and there is but one method by which they may be studied—the psychological method of introspection, observation and interpretation. Hence, even if we have to do with the one causal series, we have two kinds of facts and two distinct methods, and it seems, on the whole, convenient that the work should be divided between two men. We have abundant evidence that a given man may employ the one method very well and the other very badly.

On this view of the relation of mind and body the physiologist would not, it is true, be wholly independent of psychology; he would be occupied with series of occurrences which end in or are initiated by psychical facts, and he would be interested in these facts as he is interested in the physical stimuli which give rise to nervous impulses. They would, however, constitute no part of his own proper field of labor; and to give the total antecedents of a given bodily movement, the combined work of the physiologist and psychologist would be needed. It is hardly worthy of remark that, in the present state of our knowledge, the question as to the exact spot in the sensory-motor arc at which the psychical patch is to be inserted, is one which no sensible person will give himself the trouble of asking. On the wisdom of making mental states effects of bodily causes and setting them in the one series with these, it is not necessary for me here to comment.

If the mind be regarded as a something independent of the physical series of causes and effects, and, so to speak, breaking in upon it, the case is much the same as in the above. We have a physical series interrupted at a given point by something of a different nature, and which must be investigated by a different method. The physiologist appears to have a definite task—the study of the physical series; he may leave the examination of the gap between its two parts to the psychologist, whose work is sufficiently marked out from his own by the method employed, the method of introspection, observation and experiment, and interpretation.

So much for the theoretical boundary line between physiology and psychology. It is, I think, a sufficiently definite one. It is, however, a line, and not a fence; one may easily step over it, as, indeed, many do step over it. The question naturally arises, is it wise to step over it, and if so, when? I think this question may be answered in a general way by saying that, when, for any reason, an excursion into other territory will further one's progress in one's own, such an excursion is justifiable. If the physiologist can, through a study of psychical phenomena, arrive at some hint of their physical concomitants, or, if you will, causes, it seems quite right that he should make use of such a

means to his end. The two theories of color vision commonly discussed in books on physiology very well illustrate this point. I have said somewhere above that practically nothing is known about the occurrences between the retina and the 'hind part of the cortex' in the act of vision. I might have added that comparatively little is known about what goes on in the eye itself. What has taken place in the retina when one has become conscious of seeing the color red or the color blue, physiology has never succeeded in directly demonstrating. Both the Young-Helmholtz and the Hering theories are attempts to guess at the nature of such physical occurrences by the aid of knowledge gained in another field, the psychological. Such a mode of procedure seems proper enough, but it is well to remember that were the science of physiology more completely developed, this excursus into psychology would be unnecessary. Where such an excursus has not a physiological end in view, but is merely psychological throughout, it does not appear to me justifiable. There are a number of chapters in Dr. Foster's fourth volume which seem to be of this nature. Their place is in a text-book on psychology and not one on physiology. In the place which they actually occupy they serve, I think, only to conceal poverty of physiological material and to confuse the reader's mind as to the limits of the two sciences.

The above sentences and, indeed, the whole argument of this paper support the conclusion that, with increase of knowledge, the amount of psychology to be found in text-books on physiology will be a diminishing quantity. This does not, however, imply that psychology will grow independent of physiology, as the latter will grow independent of the former. Physics and chemistry are independent of physiology, but it is not independent of them. The psychological method includes introspection, observation and experiment, and interpretation of what is thus brought to light. And the difference between guessing roughly at what is passing in a man's mind by watching the movements of his face, and studying systematically and minutely the human body with the same end in view, is not a difference in kind. The objective method in psychology implies the employment of physiology in the search for psychological

truth ; and, as I pointed out two years since in the paper already mentioned, the every-day psychology of the practical man who needs to know something about what is passing in his neighbor's mind is, after all, psychology, and only differs from that of the scholar in being less systematic, exact and reflective. If a study of the cerebral cortex will better reveal what we are seeking to discover than a study of the face, then by all means let us transfer our attention to that. Let us not, however, grow so interested in the study of the body as to forget that we are psychologists. Let us not take up physiological work which has no psychological aim. Now and then, I think, psychologists do this. When they do it I believe they are guilty of unjustifiable trespass, and would probably better serve the world by remaining on their own ground.