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THE BIOLOGIC ORIGIN OF MENTAL VARIETY, OR HOW WE CAME TO HAVE MINDS.[1]

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It is not an infrequent combination that the most familiar things neither excite curiosity nor are understood. Our subtitle suggests an instance of this kind. The naive man commonly takes for granted that he sees the landscape, and hears the orchestra, for no further reason than that they are there before him to be seen and heard. A man a degree wiser gets so far as to recognize that eyes, ears and a brain are necessary. If a biologist be asked, to-day, how we came by this apparatus, he will answer, "through evolution." This is the maximum reach of Science at present. Yet it is nearly as naive to conceive that we have minds, such as ours, merely because we have eyes, ears and a brain, as for one to imagine that he sees just because he has his eyes open. This becomes apparent if we consider the widely accepted doctrine that all the sensory currents running through the nerves to the brain are of the same general sort, as much so as those in electric wires

[1] This paper, under the title "Psychology and Biology" and now somewhat altered from the original, was one of six lectures on "Modern Psychology and its Bearings," delivered, by the author, at Johns Hopkins University in March, 1896.

some of which ring bells while others blow whistles. For if it be asked why our sensory currents 'ring up' such different results as sight from the optic nerve, and hearing from the auditory nerve, it is plainly not satisfactory to answer, "because we have eyes and ears," if, as this doctrine asserts, the eye and ear nerve currents are alike. Nor is it much more enlightening to be told that "it is the *place* in the cortex to which the different nerves run that makes the difference in the sensation resulting from them;" not unless we are in some way told wherein and why these "places" differ. It is just in the fact of never having even inquired how these "places" came to differ, that our evolutionary science falls short in one of the most curiously interesting and important questions that can arise either in biology or in psychology.

Of course, it is a fundamental assumption of both these sciences that all our mental differences are paralleled by molecular differences among the neural activities that underlie them. But this still avoids the question why these last are different, and how they came to be so. And until some answer shall be found that shall logically connect these ultimate neural peculiarities with those peculiarities in outer objects which the world commonly conceives to correspond to our various sights and sounds, it can scarcely be boasted that we are much less naive than the ancients who thought that the objects gave off films that floated into our minds bodily. I by no means imply that this doctrine of all sensory nerve currents being of the same sort is universally accepted. But where any other hypothesis has been offered in its place, the relationship between inner sense and outer stimulus has been left as barren of explanation as even in this doctrine, where, apparently, the possibility of explanation is cut off altogether. But all these matters we are to examine categorically further on. Sufficient has now been said, by way of introduction, to make clear that it is the *variety* of our sensory responses (without which our minds would not be minds), and of their connection with the sorts of stimuli with which they are now connected, that we are, in this paper, to subject to careful investigation. It should be obvious that this inquiry must in-

volve, fundamentally, the evolutionary relation between biology and psychology; and it is for this reason that I have selected it as worthy of the present occasion.

Plunging at once to the heart of our problem, I may state that there are two possible propositions regarding the fundamental relation of our senses to their respective sense organs; which propositions are mutually contradictory and exclusive of each other; which, being fundamental and contradictory, it is necessary to decide between, as a first step toward any permanent insight into the evolutionary relation between body and mind; yet regarding which neither science nor philosophy, up to the present moment, has given any least intimation. It will be the main purpose of this paper to set forth these alternative postulates as completely as I may, within the limit of an hour; and if within that space we do not arrive at any vantage ground, where we may venture a guess at the proper decision between them, I trust that this will but the more emphasize their vast and crucial significance. To venture a prophecy, I may state that the indispensible solution of these two postulates is not likely to be reached for many years to come, nor until wider discussions and further reaching investigations shall have been ploughed under them, than now cover the fields of the great Weissman-Lamarck controversy.

The first of these postulates may be stated as follows: In the light of the little knowledge we as yet possess, it is open to conceive that, in the beginning of the present epoch of animal evolution, crude or primary protoplasm was sensitive not only to all the forms of physical stimulation which now produce sensory responses in us (i. e., sight, sound, taste, smell, touch, temperature, muscle, and other sensations), but was also capable, in response to appropriate stimuli, of an infinite, or x number of other forms of sensation which we know nothing about. In accord, and in illustration of this possibility, we may conceive that the simplest amorphous creatures now actually experience an infinite variety of transient and elementary sensations, including the few we have and a multitude of others that we never have.

Under this conception, we may look upon the rise and development of sense organs generally to mean the slow differentiation of protoplasm to the exclusive use of certain specific forms of stimulation. Thus we may interpret the appearance of eyes to mean the production of an apparatus peculiarly adapted for light waves to the exclusion of all other forms of stimuli. Through the appropriation of the entire fixed surface of our bodies to the particular sense organs which developed in our ancestry, we see how, under this proposition, our few kinds of sense should have been *preserved* to us; and how the infinite number of others with which it endows primitive protoplasm, *should be lost to us through the required forms of stimulation being shut out.*

The alternative of this fundamental formula is that we may conceive, quite oppositely, that protoplasm was capable at first of only one form of sensory response; and of but one mode of neuro-sensory activity correspondent therewith. What this form of sense was we need not consider, at present, further than to suspect that it may have been far different from anything we experience.

Under this proposition we should attribute the rise of various new senses to the development of new kinds of protoplasm, capable of correspondently new forms of sensation. Thus the advent of sight and of sight organs, here, would mean the development of a new basis of physical activities, peculiarly susceptible to light stimulation, and the psychic counterpart of which would be a new kind of sense.

These, then, are our opposing hypotheses. According to one, *Life began with many fleeting, transitory senses, and we have become shut in to a few permanent and highly developed ones.* According to the other, *Life began with one simple sense, and has opened outward with the development of our various and complicated senses.*

It will now be proper to bring forward the implications of these great rival theories in a way to justify the lofty prospectus which we have announced for them.

First we should note, as already has been intimated, that both propositions, alike fundamentally, assume different phases

of neural activity for every psychic happening or sensation, and for every sense quality and shade of quality. That is, one sort for red, another for blue, and others for every sort of taste, smell, and so on.

Next we may note that both propositions equally involve the fact that physical activities immediately underlying our psychic states are enormously complex. Demonstrably, by modern experimentation, they rest upon a chemical basis, intricate beyond all comparison; each molecule comprising various atomic components which, in number, according to highest authority, mount among the billions, and out-run all adequate comprehension.[2]

Next we may observe that in proportion as these molecular activities are complex, so will the molecular differences be great which correspondently lie *between* our different elementary sensations, that is, which correspond to the psychic differences between sights, sounds, smells, tastes and our other major classifications of sensory elements; and between the reds, blues and greens, sweets, sours and bitters, and other minor differences observable in each subclassification, down to the limits of their infinity.

Of course, the old doctrine of specific energies, handed down to us by Johannes Müller, taught us to expect that every different quality of sense must be paralleled by a different form of neural activity. But by emphasizing the enormous complexity of these neural forms, and the vast molecular differences between them, which must be implied by the differences to be observed among our several senses, I wish to bring forward what appears to me to be one of the most important truths in mental science, and one which, in so far as I know, has never before been caught sight of, or taken into account in deciphering the great problem of mind and body.

For finally we may observe that, *Intrinsically and within themselves, these molecular differences, correspondent to the differences among our psychic elemeuts, must necessarily have constituted determining factors of animal evolution; and must have decided what peculiar psychic elements should be selected, and perman-*

[2] See "Man's Glassy Essence," by Charles Pearce, in *The Monist*, October, 1891.

ently incorporated into our psychic existence. They must, therefore, explain the variety of our psychic elements, and the origin of their connection with the central mechanisms on which they now depend, and with their respective sense organs. Consequently, also, they must furnish a key for deciding between our two rival theories of the origin of our psycho-physical organism. And altogether, a study of this subject must unlock to us wide and unforseen fields of scientific truths.

That the evolutionary values of his various "energies" should not have been perceived by Müller is not surprising, but that they remain unconsidered to-day can only be explained by the vagueness of current notions regarding them; and it must now be our task to come to a realization of the conditions which they involve.

Bearing in mind that, as is now demonstrable, the molecular basis underlying each one of the sense-elements of which our brain is capable comprises billions of variable physical constituents, we may first note that this truth must have its influence within the sphere of *Spontaneous Variation.* We do not yet fully know the laws which govern variation, and there is difference of opinion as to the role it plays in developing organisms. But at least the followers of Weissmann should appreciate that not all neural "energies" of such vast complexity could have equal chances of advent, and that this fact must have been a major condition in the origin of those different classes of sensation with which we are now equipped.

Secondly, we may appreciate that the variants in question must constitute determining factors of organization within the circle of *Nutrition.* Not only must our intricate brain components be born into our organism, but they must be maintained there in face of exhaustion and fatigue. Loss of the thyroid gland demonstrates to-day how special are the ingredients necessary for maintaining the general functions of intelligence; and there is ample room within the mysteries of Aphasia to suspect that the requirements are even yet more specific that must be provided within localized regions of the cortex for our different senses. Every notion of modern science suggests that these activities must be specifically com-

plex and vastly variable, and assuming them to be so, the conclusion is inevitable that they should neither be produced or maintained with equal ease; and that, therefore, within the course of adaptation and survival their specific characteristics must have determined, respectively, their own advent and perpetuation.

Third comes the vast region of fitness and selection, which must rise from the relative serviceableness of these several complex activities to *The Environmental Forces*, to whose stimulation they must join themselves for the creature's welfare and preservation. That this sphere is likely to prove of central interest in our problem should be obvious, and because we are to give it much attention further on, we may limit ourselves to the bare statement of it here.

A fourth region of evolutionary choice among possible sense energies must be found in the relative adaptiveness of their molecular complexities to the development and perperfection of such peripheral or end-apparatus processes as are requisite or of profit for mediating between them and the environmental forces. Within this field, more than anywhere else, perhaps, we are likely to discover the functions which most intimately determine the diverse forms of our perceptive organs, and that fix thereby the sorts of mental pictures dependent thereon. This, also, we are to discuss with some fulness presently.

Finally, the factors in question must have determinative bearings within our general physiology. These it will be necessary and important for Science in time to work out; but they are of a nature so remote from psychologic problems proper that they need not be intruded further upon the limited space of this present paper.

Their self-determinative fate within the realms of their Zoologic Genesis, their Physiologic Maintenance and Organization, and their Environmental Adaptation, these, then, are what we have chiefly to study, in our present quest. And these lines being laid down, the following considerations pertinently thrust themselves forward, for our further guidance. It should be obvious at the outset that the nervous currents or impulses

passing from the periphery to the cortex, and arousing there the activities lying nearest to the final sensory results, should be of crucial importance in our investigation of the molecular differences assumed to underly our different senses. Regarding these nerve currents two main opinions are held. Professor Wundt conceives that all the sensory cortical cells are equally potent of all the different sense-forms at our birth; and that the sort of response they actually give is dependent on the form of the impulse that reaches them through the peripheral nerves to which they happen anatomically to be joined.

According to an opposite view, advocated by Prof. James and many others, and to which in our introduction we have already made allusion, the currents in the different sensory nerves are all alike, and the sort of sensory responses they mediate are wholly dependent on the respective places in the cortex to which the different nerves run. The fundamental fact being, that each center is congenitally destined to its one specific form of activity, and the different centers to their permanently different forms.

We can get a sharp notion of these opposing views, as the text-books commonly point out, by imagining the visual and the auditory nerves to be cut somewhere in their course, and the cut ends to be crossed and joined together again so that thereafter the visual impulses will reach the auditory center, and the auditory impulses the visual center. Under this new condition, according to Prof. Wundt, we should both hear and see precisely as before; because both of these cortical centers are capable of both results; because what happens depends on the different forms of the currents that are determined in the peripheral sense organs; and because these run through unchanged, in spite of the crossing and that they are carried to new places. But, according to Prof. James' view, where the currents in the different nerves are all alike, and the results depend wholly on the place in the cortex in which they arrive—under the crossed conditions one should now "see the thunder and hear the lightning."

The chief facts on which the latter notion is founded is, that while the sensory nerves generally are sensitive to several

kinds of artificial stimulation, the sensation resulting thereby is always the same for each nerve. For example, the cut stump of the optic nerve will respond to pinching, pricking, burning, and to chemical and electric stimulation; but always with an indefinite visual flash, whatever the form of stimulus that is applied.

The chief facts upon which those who agree with Prof. Wundt base their opinion, are summed up within certain alleged phenomena of "Substitution," there being some reason to believe that when parts of the cortex are destroyed, either by disease or by experimentation upon animals, certain remaining parts take upon themselves the former functions of the lost parts, and change their former habits and modes of response in so doing.

Neither of these opposing theories are conclusively substantiated at present, since there are counter replies for each. Thus it is open for Prof. Wundt to explain the fact of the optic nerve replying invariably with sight sensations to every sort of artificial stimulation, by saying that this is only true in the adult, where the cells, by having only one form of stimulation brought to them by the nerve to which they are permanently fixed, have been educated persistently in one form of response past the age when they have lost the power of plasticity and of shaking off the old habit to take on a new one—a power which at birth they eminently possessed. And, on the other side, it is open for those who believe in fixed congenital responses to suspect that all the facts of Substitution are due to the lost function being taken up by remaining cells of the same kind, and especially by the correspondent cells of the other half of the body; *i. e.*, those of like kind in the opposite lobe of the brain.

Such is the state of this controversy up to date; and its confusion would be out of place in our present study if we were not now able both to bring this problem, by new considerations, to a solution, and also to demonstrate its cogent bearings upon our main subject. We speedily come to this by recalling that we have already determined that the molecular differences, corresponding to the differences between our several senses, are

certain to have been determining factors of the evolutionary relationship between our minds and bodies in any case, and by then passing on to observe that the sphere of this relationship would be vastly different respectively under our two rival theories regarding afferent nerve currents. Indeed, would be so different as to demand consequences, under one of these theories, so incompatible with existing facts that we shall be able to discard that theory altogether, thus reducing our difficulties, and giving us in the remaining theory an invaluable guide for our main investigation.

This difference in evolutionary sphere comes to view the moment we recognize that under the Wundtian notion (of the sensory currents being different all the way through the nerves to the periphery and to the different environmental forces which respectively stimulate them) the forces determining the selection and perpetuation of these currents in the organism would include all the five regions in which we discovered it was possible for our "molecular differences" (specific energies) to work with selective or evolutionary fitness—namely, the regions of Spontaneous Variation, of Nutrition, of Environmental Adaptiveness, of End-Organ Adaptiveness, and the vaguer sphere of our general physiology. On the other hand, and under the notion that the afferent currents are all alike, it should be plain that this likeness would cut off our central processes, regardless of their molecular differences, from all relative serviceableness either to the great world of environmental forces or to the intricate and indispensable mediating processes in the end-organs, and would thus reduce the sphere of their evolutionary reciprocity to the three remaining and apparently lesser fields.

The significance of this is so great that we shall do well to set forth the connection between our senses and their stimuli, under this point of view, by an illustration. We may do this by imagining two wires coming to this desk, one of which is attached to a bell that is rung in accord with the velocity of the wind outside by an electric current, brought through a wire from a proper apparatus on the roof—a heavy wind ringing the bell violently, and a calm giving no ring at all—and

the other wire we will imagine to be connected with a visible index, the rise and fall of which is determined by the rise and fall of a barometer and other electric apparatus, also situate on the roof. Under this illustration the ringing of the sonorous bell and the moving of the visible index are the analogues of our sensations, the electric wires correspond with our nerves, the wind-gauge and barometer with our end-organs, and the wind and temperature with their external stimuli. And since, under these conditions, by merely changing the wires here at the desk and connecting the barometer with the bell, and the wind-gauge with the index, the "sensory" results would be completely reversed from what they formerly were, so, therefore, we have here a perfect example of what Prof. James means, by saying that all depends on the *place* in the cortex with which the currents or wires are connected. And, going now a step further, these conditions also illustrate what Prof. James has wholly neglected to consider, namely, the evolutionary influences which *made* the "places" in our cortex different, and those which first connected them with the particular end-organs and stimuli with which they are now permanently connected; and these, we quickly perceive, are the important points in our great main problem. Precisely what we want to know is how we came to have the variety of senses that we do have, and how they came to be joined to the particular stimuli to which they are joined. From time out of mind mankind has naively taken for granted that the now existing relationship between sensations and their stimuli is an eternally permanent one of immediate cause and effect. But, as we have pointed out, this cannot be the case if the currents in all the sensory nerves are alike, and if, as Prof. James contends, it is alone the "place" in the cortex which determines the sort of sensation that shall respond to any sort of current or stimulus which may run to it. In this case it should be plain that it is in the characteristic differences of these "places" and in the evolutionary origin of the same, and of their permanent connection with their present peripheral organs, that the secrets must lie which we are in search of. Surely no one, under the conditions of our illustration, would

investigate alone the wind and temperature apparatus on the roof in order to discover why we hear the bell ring instead of see the index move. But, rather he would extend his investigations to discovering how the "nerve" connections originated that now exist, and how the internal apparatus, to which they run, came to be so different that in one case we "see" and in the other "hear" from the same sort of incoming current.

Enabled by this illustration to look with greater clearness into Prof. James' hypothesis, and into some of its implications, we may now go back to the assertions that vastly different spheres of evolutionary influence would be involved as between this theory that these currents are alike and the rival theory that they are different, and to the assertion that certain consequences are logically demanded by the "alike" theory which are so contrary to existing facts that it must be discarded.

What has been neglected by Prof. James is, as I have said, the *evolutionary or selective value* of the sensory currents. If these currents were all alike, then, manifestly the molecular differences which we are obliged to assume in the cortex as underlying our different sensations would be cut off from all diversity of influence either from the end-organ processes or from the environmental forces. *And this is the same as saying that they would be cut off from all selective relationship with these great spheres of influence, and that our end-organs and environment had nothing whatever to do with the origin of our different senses.*

Now, it must not be too quickly inferred from these words in italics, that it would be impossible to account for the evolutionary selection of our several senses within the narrowed sphere of influences remaining after cutting off the peripheral and outer forces. Such an inference would not only be wrong but also would confuse and obscure certain considerations that we are to come to further on, and in view of which it is imperative for me to stop long enough here to point out that the sphere of Spontaneous Variation alone *might* be sufficient to account for the variety of our senses and their present external connections, if *only their origin and not their preservation* needed to be accounted for. And this is done in pointing out that these connections might be originally due wholly to the

period at which a spontaneous variation made a new kind of "sense energy" possible. Thus, the present connection of cerebral sight with the optic nerve and with the eyes, and with the light that falls on them, might well, for all we know to the contrary, be entirely due to the chance appearance of a new form of "energy" or molecular possibility in the cortex just at a time when the development of optic end-organs made a connection with the new cerebral development available, and the exigences of the outer environment made the new linkage of processes of service. Such a connection of inner sense to outer stimulus would be as accidental as anything can be, yet it might be adequate for explaining the facts of our problem *were no influences to be considered that might disturb the permanency of such connections.* And this brings us finally to the influences which most surely would have disturbed the permanency which actually has been maintained, had this theory that the sensory nerve currents are alike been really in force.

These disturbing influences become apparent when we consider the uniformity of the functions that would be left to central nervous processes under the conditions of this theory. No one has ever contended that the outgoing currents of the motor nerves are of diverse kinds. If, therefore, the incoming currents were also all alike, there would then be left to the central processes the entirely homogeneous switch-board function of connecting like currents with like currents. And, under such conditions, and cut off from all diversity of external influences, it seems scarcely possible that some one form of molecular activity or "sense energy" out of the many that variation may have given birth to or protoplasm been originally capable of, would not prove most suitable to this one purpose, and as a consequence become perpetuated to the exclusion of all other less suitable kinds of neural sense-forms. Or, put again more simply, *since moleculur forms are sure to have been evolutionary determinants, therefore, if all the nerve currents were alike it seems certain that the cortical processes must also have become alike.* And since this manifestly is not the case, therefore we must abandon Prof. James' theory.

(*To be Continued.*)