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THE SCIENCE OF MENTATION AND SOME NEW GENERAL METHODS OF PSYCHOLOGIC RESEARCH

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By mentation I mean the totality of the conscious and subconscious adaptive functionings of a living organism.

Bio-psychology is that department of the science of mentation which studies organic structures and their environments in order to determine the relations which exist between these and the mentations which accompany them. It studies such structures and environments which nature provides and so far its method is that of observation, but it also artificially varies organic structures and environments, and to that extent its method is experimental. As experimental bio-psychology, it varies structure to determine function; and its scope includes three great sciences:

1. *Biologic Psychology,* which is that department of the science of mentation wherein our knowledge of mind is obtained by a scientific study of (A) organisms and their anatomical and molecular structures as exhibited by nature, and as varied by definite experimental conditions artificially produced; and by a study of (B) the cosmic environment of such organisms as exhibited in nature, and as varied by definite experimental conditions and also by a study of (C) the mentations of organisms as exhibited in nature in environments that have not been artificially disturbed, and as exhibited under the definite experimental conditions of organism and environment before mentioned. In other words, this science studies the individual organism as *one* factor in producing mentation of a definite

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kind; and the cosmic environment as a *second* and (at least) equally important factor in the production of that mentation in a particular organism and environment; and the mentation as the *third* factor. Annihilate the second factor and the third would be impossible. Mentation is a product of the interaction of the individual organism and the cosmos of which the organism is a functional part.

The conception of this science which this classification promulgates demands a more exhaustive study of the organism (a) as part of the totality of organic life upon earth, and *(b)* as an individual whole, and of its *(c)* anatomical and *(d)* molecular constitution. It demands what is almost a new feature in biology and psychology, namely, a systematic study of the environment of an organism, and the coordination of such data with the data derived from the study of organic structures and the mentations of organisms. The adaptive activities of organisms and organic parts must be coordinated with the conditions of the environment. This department of research seeks to discover the laws of mind by observing the modifications of mentation which occur when organic structures and their cosmic environments are varied either artificially or naturally. It includes within its province, as one of its subordinate departments, what has hitherto been called ‘‘physiological psychology,” and most of ‘‘psycho-physics.” Biologic psychology, is, of course, physiological, but it is also anatomical, climatological, pathological, chemical, morphological, physical, geographical, zoological, botanical, paleontological, etc. The word “biological” is intended to be more comprehensive than the word “physiological” according to its usual significance, but it is to be distinctly understood that in keeping with the best modern thought *all* of the activities of an organism come within the province of physiology. The term physiological psychology does not sufficiently indicate the fact that in studying mind we must study cosmic environment, anatomy, morphology, organic physics, bacteriology, geographical distribution, and all the phenomena of organic life in direct relation to mentative phenomena.

Every structural or morphological difference is accompanied by a difference in function and even in the same macroscopic and

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microscopic anatomy there is a further variation of function with every difference of a chemical and quantitative kind. By a study of all organisms with their molecular and molar structural differences throughout the entire scale of organic life, and by a study of the environments in which given organisms are found; and by a study of the particular mentations which occur in given organisms in given environments, we obtain a knowledge of mind as related to structures and environments of the kind which we have studied; and in so far as we may be able correctly to generalize, we may obtain a knowledge of the laws of mind which must characterize mentation everywhere and everywhen.

Observational biological psychology observes the organisms which nature has furnished, and *as* they are furnished. It is familiar only with such organisms and environments as it finds.

Nature does the experimenting. Nature varies environment and evolves organisms, and the organisms exhibit certain phenomena in certain environments—we inventory what we see, and from a course of scientific thought about the data we arrive at generalizations concerning mind. The kinds of organisms and structural variations which we might wish to see in order to have certain questions answered we do not always find. Whole geologic eras have not furnished such environmental changes as would settle certain doubts and answer certain questions I have in my mind—but I can in a short time create such conditions of environment, and by doing so I enter the domain of experimental biological psychology. Nature does indeed make variations innumerable, both in structure and environment, but seldom does she make that particular variation which the student may happen to need to complete the investigation on hand—she pays no attention to the logical needs of our researches when she evolves organisms. But, accepting nature as we find her, and observing what she offers, we may make progress in knowledge of mind if we properly direct and organize our observation.

Experimental biological psychology does not depend upon nature alone to furnish for our study the incidents and phenomena of organisms and their environments, but regulates natural things in such a manner as to "artificially" produce such phenomena as

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may be desired, or rather such classes of phenomena as may be necessary to give continuity to a systematic investigation of a given subject. In observational biologic psychology we simply observe what happens without our interference; in experimental biologic psychology we also practice observation, but we do something more, namely, we artificially vary the organic structures and environments and observe the concomitant variations of mentations.

In this domain the new method of research was definitely initiated by my experiments in the artificial transformation of lower organisms[1] by artificially regulated selective propagation in order to determine the precise mentative variations which accompany the evolutionary rise of given structural variations.

This method enables the experimentalist to vary and alter the structures of an organism without vivisections and mutilations, which latter methods give, not normal functional results, but pathological conditions. But to place organisms in a circumscribed environment whose conditions can be regulated and maintained, and selectively propagate them with reference to the development of some structural characteristic, *gradually augmenting* the specific conditions of the environment which demand the excessive

development of that selected characteristic until all the individuals of a multitude succumb except the few able to survive; again propagating a multitude under more severe conditions and then suddenly increasing the specific condition to which they must become adapted, until all but a few are killed, and so on, until the particular structural character has been enormously developed, enables the student to vary structures without vivisections and mutilations and to study the mentations as they arise, and thus arrive at a knowledge of the relations between structures and mentations.

The retrogression and gradual disappearance of a structural characteristic from an organism by this method also furnishes excellent data for the study of the mentations which normally accompany a given morphology and anatomy and metabolism. The contrast

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[1]First account of which was given in a lecture to the Philosophical Society of Washington. May, 1894, in which I described the results obtained in artificially evolving and retrogressing the *Volvox globator*

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between a structure retrogressed, and the same highly evolved, brings into conspicuous notice the precise mentative peculiarities of a given structural condition.

The gradual differentiation of a structural characteristic into divergent lines of evolution and retrogression by the method of artificial transformation of organisms enables the student to witness the rise and concomitant modifications of the accompanying mentations.

This method enables the student to select any characteristic of an organism, whether anatomical or chemical, and by retrogressing or evolving it, accentuate its mentative characteristics.

This method brings into conspicuous notice the relation between specific environmental conditions and structural modifications on the one hand, and the relation between environmental conditions and mentative modifications on the other hand. Structure and environment react upon, and modify, mentation; and, as will be seen, under psychological biology, mentation reacts upon, and modifies, structure and environment. Action and reaction are equal and opposite.

2. *Subjective bio-psychology,* which is that department of the science of mentation whereby our knowledge of the mind is obtained by a study, not of the structural and mental phenomena of other organisms, but of the introspective phenomena of our own minds as we alone know them in our own consciousnesses. It

makes a study of the introspections of organisms as recorded and experienced by those organisms themselves—and this almost entirely limits this science to the human race as subjects. The individuals of different races and nationalities and occupations and sexes and ages and pathological conditions make a record of their own subjective experiences of consciousness—and these records compared with the student's own introspections constitute some of the data of this science. Such a record when once collected will constitute a natural history of the human faculties. It needs much to be made. It must study also the introspections which accompany particular anatomical, chemical, geographic, climatological, dietetic, and other conditions to which the individual may be subjected. It must

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observe these as presented by nature, and as varied by artificial experimental conditions. It must study the relation between environment and introspective states, by artificially varying the environmental conditions and recording the concomitant mentative (introspective) changes. The different metabolisms of the system affect introspections; so do different attitudes, gestures, colors, sounds, temperatures, humidities, electrostatic conditions of objects and the atmosphere, altitudes, smells, tastes, touches, movements, and so on, *ad infinitum.* In brief, this science inventories introspections, and finds out what kinds and degrees and successions of introspective states accompany certain anatomical and chemical conditions of the organism and certain conditions of the environment. The new method of experiment consists in artificially varying organic and environmental conditions and observing the concomitant variations in the introspective states of the student.

3. *Sociological psychology* is that part of the science of mentation which arrives at a knowledge of mind by studying the social organism of animal life as a whole, and of each species of animal and plant in particular, so as to obtain scientific knowledge of the social or group-anatomy of societies of individuals of the same or different species, and of the relation of these individuals to the whole social organism (social chemistry). It studies these phenomena as presented by nature and as varied by definite experimental conditions artificially produced. It also studies the environmental conditions of such social groups as exhibited by nature, and as varied by experimental conditions. It varies by the method of artificial transformations of organisms the social whole of a species, so as to produce new social structures and new environments, and correlates the data thus obtained from social anatomies and environments with the concomitant mentative

phenomena. This science considers groups of individuals as anatomical wholes, and its new method of research consists in artificially transforming these social wholes and their environments and studying the concomitant mentations. It studies groups in their normal and abnormal conditions. It varies social structure to determine social function, or group-mentation. The social unit is one factor; the cosmic environment is

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the second factor; and the third factor is the social, or institutional, mentation which results. Societies of *zoogloea*, and groups of plants, constitute the material of this science, just as well as groups of the genus Homo.

I call especial attention to the fact that these three sciences constitute three distinct spheres of experimental research by three different methods, both of observation and experiment, and that from three distinct standpoints we thus obtain a knowledge of mentation. I would also call attention to the three new methods of experimental research, and how they clearly outline the scope and method of bio-psychology.

These three sciences of bio-psychology study mentation from the standpoint of *structure* to determine concomitant *function*. The structures of organisms are studied to determine (1) mentations as observable adaptive phenomena, (2) to determine introspections as known to the student, and (3) to determine mentations as part of a social whole of which the individual forms a part. It studies structure as correlated with the mentations of species of organisms, and as correlated with individual introspections, and as correlated with social mentative phenomena; and studies the structure of social wholes as composed of individuals. Structure is studied (as varied by nature or experimentally) to determine the corresponding kinds of functioning, and the quantitative relations between structure and mentation, in terms of physics and chemistry. It must be remembered that whatever mind may be, it cannot manifest apart from structure, and according to the degree of adaptability of the structure mind manifests. The thought of man cannot occur in the brain of a frog, and for higher mentation to occur in a given brain, a higher order of structures must exist. Remove from a human or animal brain any portion of the cerebral cortex and you remove a certain class of memories, and a certain kind of mental capacity disappears. Structures react upon mentation and modify it,—mind embodies in structures.

Having described the bio-psychological sciences, I will now still more briefly define the psycho-biological sciences. The three psycho-biological sciences study organisms from the standpoint of

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mentation—they study function in order to determine structure. Biology becomes a psychological subject. Mind is studied in order to find out what organisms are. In the bio-psychological sciences organisms are studied to find out what mind is. If we had no experience with organisms we would know nothing about mind. If we had no experience with mind we would know nothing about organisms.

Psycho-biology studies structures from the standpoint of mind, and interprets organic and cosmic phenomena in psychologic terms. This is the true basis of research. It is the mind that interprets phenomena. It is the mind that creates all sciences and institutions. The mind must have experience with itself before it can have experience with anything that is not itself. From the standpoint of consciousness we survey and know the not-self, and only in terms of mind can we know and define anything.

The psychological sciences study mind as varied by nature, and as varied artificially, in order to determine the corresponding structures and environmental conditions, and to interpret them in psychic terms; and to formulate the quantitative relations between mind and its embodiment in organic structure and between mind and the environment of its embodiment. These three sciences are:

4. *Psychologic biology*,—which, in its subject-matter, method, and standpoint, is the exact opposite of biologic psychology,—studies the different kinds of minds and the different kinds of mentations in each given mind, to determine the nature and significance of organisms and environments. The purpose of research in this domain is not to find out directly what mind is, but from ascertained mental data and from psychic experiment to learn what organisms are, and what the different conditions of environment signify. Organisms are classified, not primarily according to genesis, or morphology, or distribution, but according to mental characteristics. Biologic classification and taxonomy becomes psychologic. Organisms, being mind-embodiments, their taxonomy is based upon the kind and degree of mind which has been embodied. The mentation is the basis of classification. Organisms are interesting in this domain because of the way in which they have structurally embodied a given amount of mind in any class of mental functioning.

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Psychologic biology studies the anatomy of minds, and the elements of conscious and subconscious mentations as presented by nature and as varied by definite experimental conditions, and determines the concomitant conditions of environment and of organic structure.

The new method of research in this realm consists in varying artificially the mentation of an organism and studying the structural changes produced by these varied mentations in that organism and in the environment. Functioning creates and precedes structure. The organism is caused to engage in special kinds of mentation, and is induced to exercise those special kinds of mental functioning to an unusual degree and for a long time, and then its cerebral and subcerebral structures are histologically and chemically compared with those of an organism of the same age and species which has been deprived of the opportunity to exercise those particular mental faculties, and thus can be determined the exact relations between organic structure and metabolism on the one hand, and mentation on the other hand. This new method of research is of greater importance, perhaps, than any of the others. Out of it grows an art of brain-building or mind-embodiment, and other important scientific and practical results. It places psychology upon an experimental basis that enables us to determine functional localization of mental faculties and quantitative relations between mentation and structure.

Great advancements in knowledge are ever associated with new methods of research and new technic. The history of our knowledge of histology amply illustrates this. Out of the new method which characterizes this branch of the science of mentation many important results have been obtained, both to science and art, and as yet the possibilities of the method have hardly been inaugurated.

To restate the method more elaborately, it may be described as follows: It consists in depriving an animal from birth until death of some one definite kind of mental activity, and then comparing its cortical structures and cortical chemistry with that of another animal of like age and species which has not thus been deprived of the using of that function of the mind, and noting the structural differences

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between the two. Of course, important results are obtained by examining also the sub-cerebral ganglia and other nervous tissues, and even any and all organs of the body down to the changes in individual muscular fibres. This enables one to determine the structural relations between a given mental activity and brain-development when that activity has been normally exercised and when it has not been exercised. The same method is extended and made more instructive when both of the animals just mentioned are compared with an animal of like age and species to which has been given an extraordinary development of that same definite mental function by causing it to excessively exercise that same faculty of

which the first-mentioned animal was deprived. One result of these two ways of applying the method of research is, that it illustrates forcibly the fact that an unused faculty leaves some part of the brain deficient in those psychic structures which are to be found in that part of the brain of an animal which has used that faculty; that wrong use of a faculty develops abnormal structures in that part of the brain where that function has been structurally embodied; and that extraordinary use of any one mental function creates in the corresponding part of the brain an extraordinary development of cortical structures in which that extraordinary mental faculty is embodied. It proves that more brains can be given to an individual than it would otherwise, by any natural development, have possessed.

In one series of experiments seven shepherd puppies were confined in a completely darkened room from the moment of birth until they were nine months old. Triple doors guarded the darkness of the room in which the puppies were confined. This permitted the mother to go in and out without allowing light to enter the room. The front doors were opened, and when the mother entered the hall-way the doors were closed behind her, and she was allowed to remain there some minutes until the phosphorescence had subsided, and then she was admitted into the second compartment and the doors closed behind her. After a few minutes she was admitted into the room where her children were. Thus for nine long months these puppies were deprived of light. They were then chloroformed,

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and their brains, spinal cords, and other ganglia, were prepared and preserved for microscopic and chemical examination. Their eyes were also preserved. A second group of shepherd puppies of the same age were allowed to lead a usual life normal to the average dog, and without deprivation or special training of the seeing function. At nine months they also were chloroformed, and preserved for examination. A third group of the same kind of puppies were subjected to a prolonged training of the seeing functions. The hall leading into one room of my laboratory was covered with squares of metal, each square insulated from the others, and colored. These squares of metal were connected with an induction coil, with the exception of those of a certain color which were not thus connected. It was so arranged that a dog might jump from one square to another of the same color and thus pass through the entire length of the hall without getting an electric shock. To do this the dog had to discriminate between that color and all the other colors tinted upon the metal squares. An attentive dog after having been shown several times would learn to avoid

the slight shock which he would invariably get when he stepped upon the wrong color. This enabled me to know whether the dog actually discriminated between given colors, and also enabled me to compel him to practice this discriminating between colors several times daily for five months. I was thus able to determine whether the dog actually saw all of the colors, and to exercise him in the function of seeing the colors and discriminating between them. It enabled me to compel other dogs to see only certain colors and to discriminate between certain colors only, and thus determine the functional localization of color-functions. It enabled me to cause the dogs to associatively integrate their color-memories with definite motor-memories from the movements necessary to avoid getting shocks from certain colors on going through the hall.

I varied this device somewhat by feeding the dogs from under inverted pans which they were compelled to turn over in order to get a mouthful of meat that had been previously placed under them. All of the pans were rubbed with meat to prevent the dogs from selecting those with meat under them by the sense of smell. Meat

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then having been placed under, say the yellow pans only, the dog was shown where to get his breakfast. For several weeks they would indiscriminately turn over all the pans without reference to color. By and by they would gradually hunt out the yellow pans more frequently than those of another color, and after about six weeks of practice (being then five months old) some of them would turn over only yellow pans. Then the meat was placed under a differently colored pans until the dog had again learned his lesson, and so on, until finally several dogs were able to discriminate between seven shades of red (not purple and red), several greens, and so on. One dog learned to examine all of the pans as he came to them until he found meat, and after that he would turn over only pans of that color—he had made a generalization, had reasoned from phenomena to a principle applicable to his daily life.

The brains of these three groups of dogs were examined and the following general results were established:

The group which had been deprived of the use of the seeing-function exhibited an undeveloped cortex in the occipital seeing areas; the second group which had been allowed to lead a usual life had a more highly developed cortex in this same region—it was thicker, more vascular with arteries, veins, and lymph-channels, was more grey, and had a greater number of brain-cells. The former group could not be said to have brain-cells in the seeing-

areas, so undeveloped and few were they whilst the second group had well developed brain-cells in the usual number (for a dog). The brains of the third group had a much more highly developed cortex than the second group, it was more grey, thicker, far more vascular, and had a much greater number of brain-cells, and the brain-cells were far more highly developed. These experiments made upon many other dogs besides these mentioned, and upon other animals, fully confirm these results. In all cases deprivation of a mental function was accompanied with a lack of structural development in the corresponding part of the brain, and excessive training of that function was ever accompanied with extraordinary development of the special structural elements of that part of the cortex. Thus in the three groups of dogs just described there were ample evidences of

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brain-structure actually having been builded in the brains by the special training, and also of lack of usual development having been produced by deprivation of the opportunity to use a mental function.

Referring to the three groups of dogs first mentioned it is interesting to note that the vasculation was least in those that had been deprived of light, greater in the usual dog, and by far the greatest in the specially sight-educated dog, thus indicating greater activity in those areas in the educated dogs. The greater amount of lymph-drainage shows that the blood-supply was used and transformed into structures whose functioning required food.

The specific gravity of the cortex was difficult to estimate, and it required delicate experimentation to approximate accuracy in the matter. Obviously the density of the grey matter is quite a different thing from the density of the cortex, because the cortex as a whole is filled with veins, arteries, lymph-vessels, etc. In order to determine the specific gravity of the grey matter a small portion was microscopically isolated from vascular tissue and immersed in liquids of different densities until it remained stationary in the liquid and just submerged a short distance from the viscous surface of the liquid. In order to facilitate the attainment of the position of equilibrium of density the liquid was subjected to sound-oscillations of high pitches, which caused the small mass of grey matter to move into the truer position or degree of submergence. By this method the density of the grey matter of the cortex of the seeing-areas of the dogs deprived of light was (on the average) 1.001; in the second group of dogs it was higher: 1.018; and highest in the third: 1.027. In experimenting with the hearing, and with the leg-movements of dogs I confirmed these results with the other senses.

In the first group of dogs in the seeing-areas I could find only undeveloped neuroblasts without collateral filaments and plumose panicles; in the second group there was on the average eighty-nine moderately well developed ganglion-cells per square millimetre section, and the axis-cylinders, plumose-panicles, and collateral filaments were observed in moderate number and moderate development. Whilst in the third or educated group there were from one

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hundred and four cells upward per square millimetre section of the cortex, and these cells were far more complexly developed in their interior structure than in the second group, had more plumose panicles and collateral filaments and these were more complex than in the usual dog, and in many ways the seeing-areas of the trained dogs were at least twenty-five times (an approximate, but low estimate) more complex structurally than in the usual dog.

It was impossible to completely deprive animals from the opportunity to hear sounds, but by depriving them as much as possible, and contrasting them with another group that had been made to practice hearing and discriminating sounds, it was found that the cortex in the hearing-areas of the trained dogs was more vascular, had a higher specific gravity, was thicker, and contained far more brain-cells, etc., than the cortex of those which had been partially deprived of sounds, and far more than the cortex of any usual dog. Experiments upon the senses of smell and taste confirmed the same results. Rabbits confined in monochromatic rooms, and thus compelled to see only one color of light from birth until death exhibited a chemically different cortex over the seeing-areas than rabbits which had been subjected to a different color—the cortices would stain differently with the same reagent.

I may mention here that I employed new technic in these examinations. My staining was done by cataphoresis, that is, the electric current was employed to carry chemicals into the tissues. The staining agent is carried into the brain-substance to be examined by the aid of the current from batteries, thus staining differently than when the reagent is used in the usual way. I also sent one stain into the tissues in one direction and then sent another chemical through in the opposite direction—the two reacting upon each other produced some very delicate staining, revealing structures not capable of being seen by other methods.

Another sample of the new technic is as follows: from a prism a monochromatic ray is reflected upon the slide containing the tissue to be examined—tissue that has been hardened, cleared, and stained in any of the usual ways or by cataphoresis—and some of the structures may absorb and some reflect this ray. If not reflected

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another ray of a different pitch is tried until some result is obtained. These monochromatic rays bring into visibility different portions of the tissue—what is revealed by one color may be invisible under another colored ray. By sending upon the first monochromatic ray another ray of a different color the different structures rendered visible by the two rays may often simultaneously be viewed.

I also caused a dog to practice certain things with his right leg, and another dog, with his left leg, and found in the first case an unusual development of the left Rolandic leg-area, and in the second case an unusual development of the right Rolandic leg-area. In a case where the dog used both legs equally there was equal development of the two areas. One dog was prevented from doing walking from birth till death, and his brain compared with that of a dog that had followed a huckster wagon day after day from the fifth to the twelfth month—the difference between the leg-motor areas was enormous in all of the characteristics mentioned in case of the sight-educated and sight-deprived dogs.

One group of three dogs were caused to practice leg-motions in response to certain sounds; and another group of two dogs were caused to practice the same leg-motions but in response to colors. The cortical peculiarity was in the first case an unusual development of the fibre-tract between the leg-areas and the hearing-areas; and in the second case the fibre-tract between the leg-areas and the sight-areas was unusually developed.

These and many similar experiments confirmed me in the conclusion that the *modus operandi* of mind and brain-growth is this: every conscious experience of sufficient intensity and duration creates in some part of the brain special structural changes, both of a histological and chemical kind, and that the re-functioning of those structures constitutes memory. These last-mentioned experiments upon the fibre-tracts confirmed me in the conclusion otherwise arrived at, that the association between memories is accomplished by anatomical integration by means of fibres and plumose panicles and wave-motions in the brain-mass.

Every definite mental experience produces a definite anatomical and molecular structure in some part of the nervous system.

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Each definite emotion produces a characteristic metabolism, and a definite memory structure: the evil emotions produce *cacastates,* and the good and agreeable emotions produce *eunastates*—the former are life-destroying and the latter are life-augmenting. Right and wrong has a chemical basis and criterion.

This method of research, the results which I have attained by it, and an account of some of its applications, will soon be published in a book which I now have well under way, and hence I will close my present account of the method of research in psychological biology by saying that this method can be very much extended, and it promises splendid results in the whole domain of psychology—using psychology as inclusive of biology and every other science. All sciences can he properly studied as products of mentation, and not in any other way. All arts are the product of mentation and are applied by mentation; and all skill and work is mentation. All knowledge is mentation, and all discovery is mentation. It is the mind that succeeds in scientific work—it is not so much a question of experiment, and of the phenomena observed, as of the mind that mentates the experiment and thinks about the phenomena; and in order to promote the development of a given science by a given mind it is infinitely more important to develop and properly *use that mind* than to experiment and observe. Experimenting, if properly done, is the most perfect kind of mentating, and the better the brain, the better the mentation.

Give to any group of animals of like age and species a definite training in the use of any one mental function (or group of functions), and to another similar group a definite training in some other one mental function (or group of functions), and then compare their brains, and learn the causative relation between mentation and structural growth—learn how it is that the phenomena called *life* are caused by mind. Compare the brains of the just-mentioned animals with the brains of other animals that have been deprived of the exercise of these same functions, and learn that in any part of the brain selected there can be builded structures according to a previously determined plan. *That* is brain-building. Future

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educational systems will be based upon brain-building, or mind-embodiment.

It is obvious that these structural changes can be made in any animal or human being in any part of the brain selected, or in reference to any function or group of functions, if these functionings are done taxically and systematically so as to uniformly reiterate each element of a complex group until the entire group has been embodied in structures, and to do this by presenting taxonomically related groups of experiences from each domain of nature and knowledge is to build a normal and efficient brain, whose functioning will surpass the mentation of a book-bred or school-drilled brain whose structures are ataxic and asymmetric.

The educational systems which will grow out of the principles

of brain-building will leave no areas of the brain fallow, no cell-layers undeveloped, no departments of nature unstudied. The taxonomy of cosmos, and the natural relations of knowledges, and the natural laws of brain-growth will determine the subject-matter and method of coming school-curriculums. The given brain and mind of the pupil will become the guide for its own development, and subject-matter and method will be guided by the natural requirements of that mind. Not the text-book or the course of study will regulate the training, but the needs and nature of the particular brain of the pupil. Only by a study of the actual methods of brain-growth, as caused by mental activity creating brain-structures, can we hope to drop the present artificial and highly arbitrary educational customs and adopt a natural and normal method.

In this new method of research we have a direct way to ascertain the relations between mental action and mind-embodiment, and can thus obtain the unassailable data for the formulation of a natural and comprehensive education. One-sided trainings which leave some parts of the brain atrophied and others congested will be forever abandoned. Courses of instruction which pour into the mind disconnected elements of mentation from disconnected subjects and build up a partial, intellectual, atypic series of mind-embodiments without the complementary emotional embodiments will be abandoned. From all domains of nature and through every normal

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channel of mentation will be exercised every class of mental activity in taxic groups, according to the brain-building laws, and the brain will be a harmoniously-working and efficient organism with all of its parts in due proportion, and evil memory-structures and immoral propensities fully eliminated. I call upon investigators everywhere to hasten to take advantage of these opportunities.

My appeal is that many workers may soon take up the scientific study of mentation and reap the rewards of these methods of research. The brain is the most wonderfully complex organism known to man, and it is a machine that can be used in the production of definite results, according to determinable and determined rules. The mind, by its own activity, can build and re-build this machine according to methods formulated out of the data offered by the method of psychologic research herein outlined. We know of mind only as manifested in the functioning of organic structures, and when we build a larger and better brain by the proper kind of taxic mental functioning we give to that person more mind.

Mentation is the directive and causative factor of organic evolution: and evolution is mind-embodiment. From the lowest to the highest organism, as the mind becomes more efficient and complex the brain-structures also become more complex. The goal of any evolutionary stage of any species of life is the degree of mind embodied. Can you conceive of progress which brings ever less and less mind? It follows that out of these researches grows not only a method of education, but a standard of conduct: that act which in its immediate or remote consequences causes the embodiment of more mind is right, wholly right, and there can be no other right; and that act which in its immediate and remote consequences causes less mind to be embodied is wrong, wholly wrong, and there can be no other wrong. This is not the place to discuss this proposition. Suffice it to say that by mind I mean the totality of adaptive functioning—I mean not merely intellectual acquisitions, but acquisitions of the corresponding emotive states and conative structures and the attainment of moral character—all of which are mental functionings. In these studies we are in the workshop of progress—we are studying the laws of the great motor of evolution

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—the cause and content of all knowledge and life—namely, mentation.

The modern age will not be known as the age of steam or the age of electricity, but the age of the apotheosis of mind; the age wherein the attention of mankind has been directed to the primary cause and fountain of all progress and power and suffering and happiness, namely, mind! The standpoint of science will be changed from that of a struggle with experiments and phenomena to a struggle with the mind that makes the experiments and observes the phenomena. There will not be less experimentation and observation, but more, and it will be by better minds. The arena upon which present science directs its undiverted eyes is that of objects and phenomena in the objective world, whilst the arena of the new standpoint is that of the pupil's own mind. Make a better brain and get a better mind and learn how to use it, and observation and experiment will teach something more to that mind than to the person who neglects the most important factor of any and all investigation—namely, the mind that makes it.

5. *Subjective psycho-biology* studies introspections as presented by nature and as varied by the pupil's own subjective efforts in order to learn what his or her own organism is. The new method of experimentation in this science consists in artificially varying introspective states and observing the effects of those definite and long-maintained states upon the organism and the

environment. It requires a previous training in subjective bio-psychology so the pupil may be able to recognize and name and call into activity any given introspective state and maintain it for required lengths of time.

This method determines the relation between mental states and metabolisms and structures and environmental conditions. Each emotion produces a metabolism characteristic of that emotion, and every introspective state which the pupil can recognize and maintain, will, while thus maintained, produce definite structural effects and definite physiological and pathological results in the pupil's own organism which leads to formulation of the laws of organisms in the terms of mind. Introspective states affect metabolism, circulation, respiration, digestion, assimilation, excretion, secretion,

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growth, sleep, wakefulness, strength, health, hearing, seeing, tasting, smelling, temperature and pressure senses, dreams, movements, complexion, voice, gesture, and the environment. The new method of scientific research in this domain, as before stated, consists in experimentally maintaining and suppressing introspections and studying the organic and environmental effects in order to formulate the laws of organisms, especially of the pupil's own organism—a knowledge that exceeds in importance that of all others to the pupil.

6. *Psychological sociology* studies the mental phenomena of groups of organisms or societies in order to determine *what* organisms are, and especially what groups of organisms are. It studies the mentations of groups of individuals and institutions and mobs and families and clans and sects and religions and social integrants as presented by nature and as varied experimentally in order to determine the effect of such group-mentations upon the individuals of the group, and upon the group, and upon the environment. It interprets social wholes in psychic terms.

The method of experimental research in this domain consists in artificially varying the mentations of groups of individuals and observing the corresponding changes in group-structure and in environment. From coherent masses of cells and groups of plants to human institutions the experimental scheme is to vary the adaptive functioning and observe and correlate the effect upon the group. Mind laws are applied to the study of societies in order to find out the laws of structure and environment in relation to groups.

These three psycho-biological sciences rest upon the discovery that by varying the mentation of an animal or group of animals we can vary the growth of visible, tangible, ponderable structures of

an organism, and thus determine the causative connexion between mentation and living growth. Mind dawns before the view of the experimenter in this domain as a causative factor in life and evolution. If every action of an adaptive character is called mental, then the distinction between animate and inanimate masses or bodies, between living or "supposed" lifeless matter, is one of mind. If every adaptive action of an organism is mental, then mind is the efficient cause of evolution. If every adaptive act is the result of

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sensibility or perception or volition or willing or impulse or desire or fear or craving, and so on, then it follows that adaptation is mental and evolution is mental. Our conception of an inanimate mass is that it cannot initiate an adaptive and responsive action. Our conception of an animate mass is one that can initiate an adaptive movement, molar or molecular (every molar motion being the result of a molecular motion in an organism).

The demonstration that mental activity creates structure places the matter of evolution largely in our hands to direct and augment it. We can select grouped activities according to the taxis of nature and mind, and build a grouped series of taxic structures in the brain, and thus embody more mind and thus anticipate centuries of haphazard, survival-of-the-fittest evolution, unaided. Henceforward man can take the Archimedean lever of progress in his own hands (or brains) by directly augmenting the fundamental cause of evolution and progress,—getting more mind, and learning how to utilise it. Mind is at once the cause and the end of progress—the method and the goal!

The chemist who desires to advance his science will spend less time and labor perfecting his apparatus and experiments, and far more time to the perfection of his mind as the instrument to use in making discoveries. The insight has changed from the objective to the subjective. It is a question not so much of the number of experiments he makes, and the number of compounds he studies, but of the amount of mind he has embodied and of the way he uses his mind thus embodied. By getting more mind through brain-building he will be able to understand phenomena and devise experiments before impossible to him. The centre of scientific effort will henceforward be the perfection and building of the scientist's own brain and the embodiment of more and better mind, with which to experiment and think.

7. The *Science of Mentation,* of which *psychology* as previously known is a subordinate department, is a synthesis of the generalisations of the preceding six experimental sciences, and proceeds upon such fundamental laws of mind as have been

determined, and includes logic as portion of its subject-matter co-ordinate with all

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other sciences as portions of the science of mentation. All philosophical and metaphysical systems, all religions, languages, and institutions and arts come within its scope, and furnish its subject-matter. Whatever the mind has done belongs to the science of mind. All that man has done upon earth, all that has resulted from the adaptive functionings of organisms, from the hole burrowed in the earth by the simplest worm to the pyramids of Egypt; from the silicious shell of a diatom to the Thirty-nine Articles; from the automatic metabolism of protoplasm to the prevision that results from the highest scientific generalisations; in short, all of the phenomena of life come directly within the scope of the science of mentation. All *knowledge,* having been produced by mind, and capable of being known only by mind, and can be applied as an art only by mind, comes under psychology as a subordinate branch. The science of mentation, which might be called psychonomy, offers data for an art of mentation. Corresponding to this mind-science there is a mind-art,—but of this I may speak in a subsequent article.

I will conclude by calling attention to the imperfections and complete inadequacies of all psychologic terminologies. So great is the diversity of meaning attached to all terms relating to mind that it is very difficult to make one's meaning clear to any great number of people, and it is even difficult to make a record of one's own thinking. The same word applies to such a number of distinct mental processes, and so many distinct mental functions have no name, that it is time to introduce some terminology free from these difficulties. In my own thinking and writing I use symbols instead of words, and the system has received the approval of some very high authorities. I append a brief description of part of this system of symbolic terminology, reserving a description of the taxonomic nomenclature for subsequent presentation.

Many cosmic forces may be incident upon the organism, but only those which excite an adaptive response, act as a stimulus: let such a cosmic stimulus be named or represented by the capital letter *A*.

This cosmic stimulus may be incident upon an organism but not be of sufficient intensity or duration to excite an adaptive

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response, if so, it does not produce any impression recognised by the organism or responded to by any of its structural parts. But if of sufficient intensity and duration to produce such an impression

upon any organ then it is called a sense-impression, and is represented by *B*.

Let the transformation of this sense-impression into transmissible energy be symbolised by *C;* and its transmission through a nerve by *D;* the impression made upon a ganglion by *E*; the transformative functioning in the ganglion by *F;* the libero-motor discharges from the ganglion by *G*; the new structures caused by the ganglionic functioning by *H;* the effect of the libero-motor discharge by *I;* the re-functioning of the *H*-structures by *J*; the liberomotor discharges of the re-functioning by *K;* the effects of *K* by *L;* the structures caused by the re-functioning of the *H*-structures by *M;* the libero-motor discharges of *M* by *N*.

This is not the full symbolism for the area gone over. Thus the libero-motor discharges of *G* are transmitted through a nerve, and in the full terminology this is named, so is the impression of that which is transmitted, and so is the effect on the tissue to which it is transmitted, and so on. My purpose is to give enough of the terminology to give an idea of its scope and importance.

Resuming again the system of naming from where I left off, let the transmission from the sense-organ or ganglion to other ganglia intermediate between the sense-organ and the cortex be represented by *0, 0', 0",* etc.; the transformation of the force for transmission by *P*; that which is transmitted by *Q;* the impression on the cortical cells by *R*; the functioning set up in these cells by *S*; the consciousness of that functioning by *T;* the structure formed by that functioning by *U;* the libero-motor discharges of that functioning by *V;* the effect of *V* by *W;* the refunctioning of *U* by X; the consciousness of that *U*-refunctioning by *Y,* and so on.

Special symbols indicate the kind of stimulus, whether of light, sound, smell, etc., and the higher grades of mentative integration and differentiation have symbols for names instead of words. This conduces to great exactness in description and in thinking. The functionings called sensation, imagination, conception, ideation,

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reasoning, and so on, have each their appropriate symbology and taxonomy

These new methods of research open wide fields of richest treasure to the investigator, and offer wonderful chances for cooperative mentation and research.

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