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SCIENTIFIC APPROACHES TO THE STUDY OF THE HUMAN MIND[1]

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WE are met to inaugurate a museum of psychology. May I begin by quoting a letter which I recently received from a spirited adolescent girl, age 14? "I have many hobbies," she wrote, "in fact they are almost countless. The one I like best is keeping a museum. As you probably remember, our house is quite large. My museum (the name of it is 'A Country Museum') is one of the smaller rooms upstairs. . . . Some of the things are Indian arrow heads, a tip of an Indian ax, a hornet's nest, and some butterflies. The thing that I thought would be interesting is to try to get a stone or two from every state of the union. . . ." So I sent her a rock from Connecticut.

[1] Address delivered at inauguration ceremony of Psychological Museum and First Psychological Exposition, Garfield Park, Chicago, May 4, 1938.

There is a good deal of psychology in that letter; not so much in the rock itself. A psychological museum must deal with phenomena less substantial and less accessible than rocks and hornet nests. Can it succeed in giving tangibleness to the human mind? The Lewis Institute, your trustees and director have undertaken a project of great difficulty, but one which has important pioneering possibilities. Museums have in general been devoted to the products and often to the curiosities of human culture. A psychological museum will have to concern itself in a new way with a delineation of the nature, mechanisms and the needs of human behavior. It will have to design a new kind of transparent man. Its problem is to objectify, to make visible, the operations and the laws of the human

mind, to give us an inside look. In this age of photography, of pictorial journalism and of the motion picture, of window displays and of murals, the race wishes to see with its own eyes, to look. More eagerly than ever, we are trying to get glimpses of ourselves.

Ancient man was moved by similar impulses. When he scratched and daubed his own murals of a bison hunt on the walls of a cave, he got a little further outside of himself and a better perspective upon himself. This was his art gallery and museum. But his psychology was crude. He had only the dimmest notion of his mental life and the mental life of others. He was confused by the echo in the valley, by the reflection of his own image on the water surface, by vapor and wind. He could not have understood William James's chapter on "The Stream of Consciousness," even if it had been translated into Neanderthal. (But even William James is rather recent, for it was only seventy years ago that he returned to America from Germany with tidings of a possible science of the mind.)

Savage man is to this day literally afraid of his own shadow. He regards his shadow as his very soul, or as a vital part of himself. The natives of Nias, Frazer tells us, tremble at the sight of a rainbow, because they think it is a net spread by a powerful spirit to catch their shadows.

Modern science has done something for us. It has at least explained the optics and the physics of the rainbow. And at long last, science is also removing some of the lingering terrors and mysteries of the human soul.

Psychology used to be defined as the science of the human soul. It makes little difference if we substitute the words human mind or human behavior. It is an error, however, to think of psychology as *the* science of the mind—as the one and only science of the mind. The organization of modern sciences is such that no one science can be allocated to a distinct and detached province. This is particularly true of the life sciences and their subdivisions. Only the dictionary maker can draw sharp cleavages to-day between physics, chemistry, biology, physiology and psychology. The whole trend of contemporary science is toward hyphenation and interpenetration. Johns Hopkins recently created a chair of physiological anatomy. Some time ago such a hybrid would have been regarded as grotesque. To-day we grant that static phenomena can be studied in the making. We also recognize that the most creative advances of science take place at the growing margins where diverse fields of science touch each other and lose their separate identities. The tendency toward excessive specialization is counterbalanced by a tendency toward hyphenation which brings disciplines into union. Witness psycho-biology, neuro-psychiatry, bio-physics, psycho-somatics, etc.

Paradoxically, the highest reaches in specialization require the profoundest fathoming into fundamentals. W. B. Hardy, for example, we are informed, started his career as a biologist but ended as a physicist, studying the phenomena of lubrication and the molecular structure of silk and wool fibers. Did he go astray? Not if we grant that the characteristics of protoplasm remain a mystery without a thorough knowledge of viscosity. We can not even be certain that he has not made an ultimate contribution to psychology, via the study of lubrication! Such round-about implication and deviousness of approach are in fact characteristic of the structure or rather the physiological anatomy of modern science.

Diverse sciences show a tendency to interpenetrate. This is peculiarly true of the study of the human mind. The psyche, the behavior of a man, is a focal manifestation of the "forces" of nature. Man is part of the order of nature, the same order which determines the differential elasticity of silk and wool fibers and the stripes of the rainbow. His psychology is an integrated expression of all the factors that contribute to the ordering of life. Neither the integration nor the factors can be comprehended by traveling the narrow trail of a single scientific discipline.

There are, accordingly, many scientific approaches to the problems of human psychology. I use the term approaches deliberately to suggest the broader avenues which lead to the central city of Man-Soul. The term is not necessarily synonymous with method. An approach is a pathway; a method is a manner of procedure by which you travel. Statistical method, for example, represents a tool, a mathematical device for the clarification and formulation of data rather than the creation of data. The experimental method, when it deals with crucial and predictive issues, is in many respects supreme. We are inclined to agree with Boring's contention that "the application of the experimental method to the problem of mind is the great outstanding event in the history of the study of the mind, an event to which no other is comparable."

It does not follow, however, that the science of the human mind has depended, or will depend, entirely upon direct experimentation with specific psychological phenomena. More than any other science, psychology will be derived from basic, contributive disciplines which deal with the subordinate but determining orders of nature. The science of psychology will continue to grow by a social process of accrual. It will advance on tidal currents generated by the basic sciences. Already it has burst the confines of a somewhat conventionalized series of text-books. At the moment we do not so much need a genius who will make original experimental discoveries in the realm of mind. Rather we need a Darwin who will reveal, coordinate and consolidate the unlabeled psychological knowledge

which has already accrued, but has not yet become intellectually integrated.

There are at least five fundamental approaches to the comprehensive science of the mind, and none of these is purely psychological. From a monistic standpoint of determinism, we need not insist too rigidly upon distinctions between mind and matter or between structure and function. We are obliged to reckon with all forms of relatedness which truly reflect the universal order and the regulatory principles that pervade alike animate and inanimate nature. Without aiming at symmetrical emphasis, our comments will deal with (1) Neurophysiology, (2) Chemistry, (3) Clinical Studies, (4) Developmental Morphology, (5) Cultural Anthropology. More direct and introspective approaches we shall not attempt to consider.

(1) *Neurophysiology.* Scientific psychology arose within the domain of physiology. Must it not always have a deep root in the physiology of the nervous system? For the nervous system supports and serves the fundamental functions of sensation and movement, which constitute the very essence of mind. To be sure you can not adequately "represent thoughts and emotions as nerve cells tickling one another." E. W. Scripture in a moment of autobiographic candor went on to say, "I throw aside every book on psychology the moment I see a picture of the brain in it." We can not, however, find support for this bit of Scripture in the writings of Sir Charles Bell, Johannes Müller, Magnus, Pavlov, Sherrington or Lashley.

Sechenov in 1863, in a famous lecture on "The Reflexes of the Brain," initiated a new chapter in science. "All psychical acts without exception," he boldly asserted, "if they are not complicated by elements of emotion, are developed by means of reflexes." From this thesis have sprung some 2,000 published studies of the conditioned reflex, with titles ranging from "The Withdrawal of the Tubeworm from a Shadow" to "The Investigatory Reflex of Homo Sapiens."

Neurophysiology is to-day one of the most active fields of hyphenated science. The techniques are becoming increasingly refined. A century and a quarter ago it was an epoch-making discovery to make a simple distinction between the sensory and motor roots of the spinal cord. To-day the almost infinitesimal currents of nerves and nerve centers are registered, their rhythms photographed in curves of beautiful precision. With devices for both auditory and visual magnification, the electrometry of the brain has swiftly amassed voluminous data—more in fact than the investigatory cerebrum can immediately cope with. By the method of thermo-coagulation, individual layers of the brain cortex are being separately explored. By means of ultra delicate probing, microscopic groups of nerve cells are being identified in the medulla. Such researches are destined to give us an intimate knowledge of the architecture of the nervous system, and this knowledge will make our concepts of human behavior more deterministic and mechanistic in the best scientific sense.

It can scarcely be argued that these neurophysiological studies lie too deep below the threshold of consciousness and outside the scope of psychology. Even in the detailed studies of animal respiration, it has been found that no two dogs breathe exactly alike. Individual differences in dogs and man must be studied on a neurophysiological level.

The work and the career of George E. Coghill furnish solid evidence of the scientific significance of the neurophysiological approach. His primary interest was psychological, but even as a graduate student he says, "I became aware that the natural approach to the kind of psychological information I wanted lay through the physiology of the nervous system. Obviously, also, the physiology of the nervous system must be approached through its anatomy, about which I knew nothing." So for thirty years or more he has been making minute studies of the genetic and functional histology of *amblystoma,* a mere mud puppy. Did he go astray?

Although Coghill has not made a single experiment in psychology, in the orthodox sense, he has already had a profound influence on the biological interpretation of psychological problems. His three lectures on "Anatomy and the Problem of Behavior," delivered in London, bid fair to become classic. The thin volume which contains them belongs on a five foot shelf.

(2) *Chemistry.* Chemistry is one domain of science which is certain to make epochal progress during the next few decades. And this progress, we may well believe, will reshape our concepts and control of human behavior. The Associated Press, in its report of the recent meeting of the American Chemical Society, characterized the newly purified protein prolactin as "this mother-instinct-crystal." Here we have hyphenation with a vengeance, but with more than journalistic justification, for it is literally true that this chemical substance releases, sustains and intensifies fundamental emotional reaction in different species equipped with mammary glands. (The newspaper headlines were startling enough: "Yale hormone makes tom cats give milk and roosters brood!")

Osler, in a more than humorous aside, while lecturing on endocrinology, told his audience that their ability to listen to his lecture depended upon the functioning at that very moment of their thyroid glands. These glands secrete thyroxine, a substance which is inextricably bound up with the phenomena of attention and memory, growth and learning. A universal his-

tory of psychology would have to give a place of honor to Kendall, who isolated thyroxine in 1918.

To illustrate the psychological implications, I may cite an illustration. For a period of twelve years we have followed the mental development of a girl who was diagnosed as a cretin in early infancy. She was fed thyroxine at the age of six months. She has attained a normal level of intelligence, thanks to the thyroxine which she has taken regularly all these years, with one exception. At the age of nine years temporary myxedema developed, due to a pharmaceutical error. The druggist having made a mistake, she was fed for one month on thymus rather than thyroid substance. Cretinous signs at once emerged, but retreated as soon as thyroxine was substituted. This child's psychology literally hangs on a thyroid thread, and in observing her we have acquired a healthy respect for the chemical basis of mental life.

The pharmacopoeia lists an amazing number of drugs which have psychological effects. Some day no doubt the mechanism of these effects will be better understood in terms of molecules, atoms, chemical mosaics and chemical configurations. Neurophysiological processes will be conceived chemically. Already they are being envisaged in terms of electrochemistry and the distribution of electric potentials.

The ordering factors of life are at bottom chemical, whether they be subatomic, atomic, molecular, colloidal, paracrystalline or anatomical. These chemical factors probably even determine the Gestalten of psychology. There is, in the words of Needham, "a hierarchical continuity." Biochemistry is increasingly concerned with the morphology as well as the constituency of matter, and is bridging the gulf between sciences of matter and of form. ". . . the fields of morphology and biochemistry are not so sundered as is often supposed. Organizing relations are found at the molecular level and at the colloidal and paracrystalline level, as well as at the anatomical level. Hardy's work, far from showing that no structure existed in the cell, showed on the contrary how subtle it must be. Although we are still in the earliest historical stages of any far reaching organization-calculus, we can yet see that biological order, like (but very much more complicated than) crystal order, is a natural consequence of the properties of matter, and one characteristic mode of their manifestation."

Needham should be able to speak with authority, for he has compiled three scholarly volumes entitled "Chemical Embryology." Is it not probable that some day we may have an equally monumental work on Chemical Psychology?

(3) *Clinical Studies.* Under this heading we wish to stress the importance of clinical materials and naturalistic data rather than the peculiar merits of clinical procedure. There is no occasion to make an invidious distinction between clinical and experimental methods. Each may reinforce the other. Healthy progress in experimental medicine depends upon corrective contacts with the realities of clinical medicine. The same interdependence holds for clinical and experimental forms of psychology.

There is a whole host of "experiments" which no scientist has the ingenuity to plan nor the gift to perform. Nature performs them and presents them to him as riddles to solve. They take the shape of monsters, of freaks, of abnormal, eccentric, atypical individuals. The anomalies and the deviations may involve the total organism, they may involve only a sector or a small phase. In such moments of abnormality, as Goethe once remarked, nature reveals her secrets. That is, she reveals them if we meet the challenge and make sufficient effort to explain her experimental vagary.

The feebleminded, the insane, the psychopathic, the genius, will always provide rich materials which can be encompassed only by expert familiarity, by a naturalistic feeling for reality and by intuitive insight. Let us not underrate the vast opportunities for productive interpretation. "It would seem," as Wilfred Trotter says in an acute article in the *British Medical Journal*, "that it must be an advantage to an experimental science to have an observational side, the function of which, in addition to its use as an implement of research, would chiefly be to promote the atmosphere of intellectual liveliness which is so important as evidence of health."

The unusual elucidates the usual, the abnormal helps to define the normal, because one is a variant or exaggeration of the other. There is one type of clinical material which furnishes extraordinary opportunity for controlled, comparative observation because it comes in pairs; namely, twins. Twins are interesting in their own right, but scientifically they are most significant when used as touchstones for the elucidation of biological and psychological phenomena.

The *method of co-twin control* is an experimental device for analyzing biogenetic problems, with special reference to mental growth, learning and individuality. Twins, particularly young monozygotic twins, are almost made to order for such biogenetic studies. In identical twins, nature provides a stage for comparatively observing the effects of a developmental stimulus which may be deliberately confined to one twin. By comprehensive cross reference, the co-twin becomes a control and a check both upon observation and conclusions. This method reaches its greatest efficiency when a high degree of correspondence has been established by careful measurements prior to the experimental observations. Careless use of the method and failure to define

thorough-going comparisons in advance should be deprecated.

The method has a certain statistical validity, even when confined to a single pair of twins. The "statistical" validity resides in the numerousness of the physical, biochemical and developmental correspondences which are so extensively present in monozygotic twins. The correspondences are sometimes so refined as to be little short of uncanny, as witness the exquisite similarities of twin electro-encephalograms. Where else in nature or in the samplings of the laboratory can we match in scope and detail the biological equivalence of identical twins?

From a research standpoint we need not unduly deplore the fact that quintuplets occur only once in 19,698,322 pregnancies. Twins we shall always have with us in ample numbers of highly similar pairs for clinical and experimental studies.

(4) *Developmental Morphology.* In the study of the human mind one can not escape problems of pattern and form. When Goethe coined the word *Morphologie,* he was interested in the forms of flowers and skulls. To this day the term carries physical connotations. But the concepts of morphology can be extended to the phenomena of behavior. Morphology is the science of form. Let the dictionary remind us that form is the shape of anything as distinguished from the substance of that thing. Behavior has shape.

The shapes which behaviors assume can be investigated in their own scientific right. A morphological approach leads to the description and measurement of specific forms; the systematic study of topographic relations and correlations of such forms, their ontogenetic progression and involution; their comparative features among individuals and among species.

"Structure is only the intimate expression of function," was a leading maxim of John Hunter. In a monistic (but not mystic) sense "the mind" may be regarded as a living, growing "structure," even though it lacks corporeal tangibility. It is a complex, organizing action system which manifests itself in characteristic forms of behavior—in patterns of posture, locomotion, prehension, manipulation, of perception, communication and social response. The action systems of embryo, fetus, infant and child undergo pattern changes which are so sequential that we may be certain that the patterning process is governed by mechanisms of form regulation—the same mechanisms which are being established by the science of embryology.

Experimental embryology is now one of the most active and flourishing of all the life sciences. It has undertaken the analysis of development, particularly as it affects the anatomy of the organism. But the investigators are increasingly using functional and behavior criteria to define the somatic anatomy. This is natural, for by the principle of hierarchical continuity, there is but one physiology of development. The growth of tissues, of organs and of behavior is obedient to identical laws of developmental morphology.

It can not, therefore, be doubted that the general physiology of mental development will find its deeper roots in the same scientific soil which is now intensively cultivated in laboratories of experimental embryology. Already many of the current morphogenetic concepts have more than vague analogy to psychical processes: embryonic field, gradient theory, regional determination, autonomous induction, complementary induction, potency, polarity, symmetry, time correlation, etc. Associationism as a psychological tradition has come down from Aristotle and still has considerable vitality, as shown by a prodigious preoccupation with problems of learning and the conditioned reflex. The laws of association deal with the factors of contiguity, assimilation, frequency, primacy, intensity, duration, context, acquaintance, maturity. Needless to say, these laws will some day be reformulated in terms of the biology and physiology of development. The full coordination of animal and human psychology will depend upon such reformulations.

A more concrete paragraph may be in order here. Take for illustration the tonic neck reflex (t.n.r.), an interesting, asymmetric pattern of behavior common to man and lower animals. Magnus discovered that when he rotated the head of an experimental rabbit, a characteristic response occurred: (a) extension of the forelimb on the side toward which the head was turned, (b) flexion of the opposite forelimb. We have found this postural attitude a ubiquitous characteristic of the human infant in the first three months of life. It is his preferred posture, as he lies supine, awake, head averted. By the age of 20 weeks, his head prefers the midline, his arms assume symmetric positions and frequently meet above his chest. The human t.n.r. is not a stereotyped reflex, but a growing pattern changing with the maturity and the economy of the organism. It involves far-reaching elaborations in eye-hand coordination, prehension, prone locomotion, laterality. It displays significant individual differences in motor demeanor and psycho-motor constitution.

This behavior form, which has essential counterparts in quadrupeds, exemplifies both the bonds and the cleavages between human and animal psychology. It may also suggest the validity of a broad morphological approach to the study of the human mind. In spite of an enormous descriptive literature, one might legitimately hold that human psychology is deficient in fundamental description, because it has not reckoned systematically with the form characteristics of

behavior. We lack the grammar and the lexicon for formulating these form characteristics. We must develop morphographic methods which will simplify and generalize form phenomena. A psycho-morphological approach will also bring us closer to the ancient problem of psychic constitution and of mental types. It is indispensable for the delineation of the ontogenesis of human behavior and the comparative psychology of life cycles.

(5) *Cultural Anthropology.* Hamlet must not be left out of the play. In fact, in the Story of the Human Mind, there are two Hamlets: the Biological Adam and Culture! Culture, as Malinowski aptly put it, is nothing but the organized behavior of man. The scientific study of the patterning of human culture would seem to constitute a fundamental approach to the science of the individual mind, which mind is in part a product, in part a creator, of the culture in which it has its being. Culture is "a large-scale molding matrix, a gigantic conditioning apparatus. In each generation it produces its type of individual. In each generation it is in turn reshaped by its carriers."

We are quoting Malinowski, for he is no mean authority and he grew up in the tradition of the exact sciences, including laboratory training in physical chemistry and experimental psychology at the University of Leipzig. As the founder of the functional school of anthropology, he holds that there exist scientific laws of culture. "Culture is a determinant of human behavior, and culture as a dynamic reality is also subject to determinism."

The term culture comprises much. It includes the prosaics of food getting and of everyday family life, as well as the exoticisms of ceremony and magic. It is not assumed that multifarious masses of anthropological data must be incorporated into the subject-matter of psychology. However, the anthropologist sees in living cultures, in spite of their apparent diversity, a pervading sameness, arising out of common traits of human nature. This quality of sameness denotes underlying psychological laws which should enable us to better understand ourselves and our cultures, including religion, morals, mores and government. Thus also we may arrive at more insight into the diseases of culture as manifested in poverty, economic crises, crime and war. It is not strange that cultural anthropology claims to be the very basis of social science. But scientific anthropology, no less than psychology, is inextricably bound up with physics, chemistry, physiology and biology. Culture began with a very primitive man who has not lost all his primitiveness.

The understanding of the human mind, it therefore seems, will be attained not through the researches of a single discipline, but through the conjunctive results of a great interlocking system of sciences, a system which is itself the most characteristic cultural product of our technological civilization. No previous culture has ever achieved a product more magnificent than the present body of natural and engineering science. This achievement is our hope, as well as our despair. The despair will not lessen until the techniques of modern science can be more sincerely brought to bear on problems of behavior. Only through profound self-knowledge can the human mind bring itself nearer to individual and collective control.

THE AMERICAN MATHEMATICAL SOCIETY 1888–1938

By Professor ALBERT E. MEDER, JR.
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IT is indeed strange that organized mathematics in America is only fifty years old, especially in view of the fact that mathematics is as old as civilization itself and that in Europe the seventeenth and eighteenth centuries were periods of tremendous mathematical advance. On this continent, however, even a half century ago there was but little mathematical research. To be sure, contributions to the science had been made by Robert Adrain, Nathaniel Bowditch and Benjamin Peirce of an earlier generation and by G. W. Hill, Simon Newcomb and Josiah Willard Gibbs among contemporaries, the *American Journal of Mathematics* was in its tenth year, a few universities had been sending out doctors in mathematics for some little time, and a number of Americans had received degrees from European universities, yet this activity was scattered and somewhat sporadic, and there was little cooperation or feeling of solidarity among American mathematicians. The time was ripe, however, for the formation of an organization to draw together those Americans interested in mathematical pursuits, and to foster actively the development of mathematical scholarship and research in this country.

It was not, however, the well-known mathematicians who took the initiative in forming such an organization. A young college instructor in his first year of service, Dr. Thomas Scott Fiske, of Columbia College, but recently returned from a period of study in Cam-