Studies in the Osteopathic Sciences

THE PHYSIOLOGY OF CONSCIOUSNESS

Volume III

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STUDIES IN THE OSTEOPATHIC SCIENCES

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Volume I. Basic Principles

Volume II. The Nerve Centers

Volume III. The Physiology of Consciousness

Volume IV. The Blood

PREFACE TO THE THIRD VOLUME

This volume was prepared in the hope of presenting in a simple manner those physiological conditions which underlie the rational treatment of abnormal mental conditions.

If the manner in which the subject is presented appears too grossly materialistic in the light of the idealistic methods which have characterized most of previous discussions of the processes of consciousness, it must be remembered that whatever is really true is of more worth than even the most beautiful of untrue ideas. We do not now think of astronomy as being materialistic because the laws which govern the heavenly bodies are being determined. The glory of the nightly sky is not lessened because the stars have been analyzed and the planets have been weighed. The forces active in the formation of mountains and oceans are studied. Even the most whimsical of Nature's moods, the variations in the weather, are subject to laws which are being daily made more clear. The development of plants and animals, the physiological activities of the human body and its development, are studied, and the immutable laws are being demonstrated day by day. In all the domain of human thought, the study of conscious phenomena alone has been kept subject to the necessity for an idealistic method of treatment. This method, which long retarded the development of other sciences, should be set aside also in the study of conscious phenomena. A rational psychology must depend upon the use of those methods which have been successful in the study of other sciences.

In preparing this book a knowledge of the history of the race was found essential to anything like a clear understanding of the manner in which the phenomena of consciousness have been developed. It has not been possible to secure anything like an adequate knowledge of this history, but all available sources of information were studied. Anthropology, geology, the histories of civilized races, studies of savage tribes the world over, the development of art, music, letters, education, science, sociology, the religions of all races, the diseases and the crimes, and the methods of treatment of the sick, the criminal, and the insane, all are significant of the trend of human progress.

The study of the mental processes of criminals, degenerates, inefficients, insane and neurotics is of value in this connection, together with a study of fairly normal people under times of great stress and under the influence of the emotional states, the psychology of gangs and mobs, and of children during their development. These things add to our understanding of the phylogeny of consciousness.

The therapeutic procedures have been tested repeatedly. Their efficiency in any given case depends upon several factors, of which the most important is the exactness with which the diagnosis is made.

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INTRODUCTION

THE OSTEOPATHIC VIEW OF CONSCIOUSNESS

In the development of osteopathy the physiological aspect of the etiology and treatment of disease has been emphasized, and each year this assumes more importance. The existence of disease as an entity has been disproved; the importance of normal structural relationships has been demonstrated; the necessity for normal environmental conditions has been placed first as a preventive of disease. The biological aspect of human life is constantly found of greater importance in the attainment of the best methods of cherishing health and caring for the sick.

Health is a relationship, a condition. If the body is properly related in all its parts, and is properly related to its environment, it is said to be healthy, and its condition is that of health. If any person act properly in regard to his environment, and recognizes this relationship, he is said to have a healthy or sane mind, and his condition is that of sanity. If any person is not properly related to his environment, or if the parts of his body are not properly related to one another, he is unhealthy. If this condition affects his speech or actions in such a manner as to interfere with the best good of himself or his race, then he is called insane or imbecile.

Very many of the insanities are due to structural changes in the brain itself. It is evident that no treatment can be efficient in helping such cases to recovery. The duty of the osteopath, as of any other physician, is to recognize the condition and give proper advice concerning the care of the unfortunate patient.

Given the proper brain structure, the normal activity of the cortical neurons depends upon the good circulation of good blood, upon the normal sensory stimulation by way of the sensory organs, and upon the normal paths for the expression of the motor impulses. Given these things, the normal activity of the brain is assured. Without the normal brain structure, or with poor blood, or abnormal circulatory conditions, the function of the cortical neurons is apt to become more or less abnormal.

The physiological view of consciousness brings all of the phenomena of abnormal mentality into harmony with the osteopathic theory. If malfunction of any other organ of the body is found, the ultimate cause of the malfunction is sought diligently. No one considers that a heart beats irregularly, with many murmurs and rough sounds, because it so chooses. But if the brain cells act irregularly, with murmurs and rough sounds, too many physicians yet consider that it chooses to act in this painful and injurious manner. The place of choice is as important in one organ as in the other, and the best good is accomplished by a recognition of this fact.

Brain cells may be poorly fed; then it is needful to see that better food and better digestion follow. Brain cells may be poisoned; then the autointoxication must be eliminated or the poisonous drugs stopped. Brain cells may lack the normal stimulation; then the needed stimulation is to be given. Brain cells may be overworked, usually in certain areas only. Other areas are to be brought into activity. Brain cells may be structurally deficient. The condition should be recognized, and the person placed where he will be most efficient and least dangerous.

INTRODUCTION

In any case in which pathological mental phenomena occur there is some efficient cause for the malfunction. Bony lesions may be efficient in causing disturbances of the quality or the circulation of the blood, or in initiating abnormal sensory impulses of etiological value. Even if other causes of malfunction are present, the correction of any of these causes of disturbance may exert a favorable influence upon the progress of the disease, especially in the borderland cases.

In the so-called functional nervous and mental diseases there may be only the effects of previous experiences which are exerting an unfavorable influence upon the normal activity of the cortical neurons. The cerebral condition is that of a series of neurons not quite normally related. The effect of experiences associated with shock is usually to lower the liminal value of certain neuron systems. These systems may be concerned with almost any of the motor or sensory areas of the body, or with almost any of the lower centers. The symptoms concerned vary according to the functional relationships of the neuron systems affected.

The important consideration is the best method of securing the activity of different neuron groups, and thus to secure the rest of those so long overstimulated. The whole significance of the diagnosis and treatment of these cases is essentially the same as in the diagnosis and treatment of diseases of other organs of the body.

Subjective symptoms are as little to be heeded in dealing with these cases as in dealing with other diseases. Tests of the reaction times, of the effects produced upon the blood pressure and pulse rate, the color of the face and the dilatation of the pupils by carefully chosen statements and questions, all these are of value in recognizing the nature of the disturbance.

Instead of finding the immobility of the bony lesions, or the excessive pliability of the atonic muscles, or the knotted feeling of the irritated muscles associated with the bony lesions, or the excess or deficiency of the secretion or movement of any organs of the body, there are found in the neurasthenics the increased irritability of certain cortical areas, the excess or diminution of activity on the part of certain inhibitions, the tendency for environmental stimuli to be referred to certain motor reactions rather than to others, or to certain lower centers. Or, as it is often found that almost the whole spinal column may lack pliability, or lack normal tone, so the entire cortex may be affected by toxemias, or by circulatory abnormalities, or by other causes of malfunction.

The overstimulation or overinhibition of the cortical centers is as efficient a cause of malfunction as is the overstimulation or overinhibition of the spinal centers. The efficient osteopath is the one who recognizes the cause of malfunction, corrects it if possible, and advises the best care for the incurable cases.

CHAPTER I

THE FUNCTION OF THE NERVOUS SYSTEM

The only duty of the nervous system is to unify diverse structures. Unicellular organisms make direct reply to environmental changes. Each variation in the surrounding fluids is met by changes in the activity of the cell which adapts its internal conditions to those changes, unless these be so great and so destructive as to preclude the possibility of adaptation, and thus the possibility of continued life. The series of internal changes which make reply to the external changes is life, in Spencer's use of the term. In answer to variations in any environmental factor the unicellular organism makes such movements or displays such inactivity as best serves the needs of the organism as an individual of a certain race. The history of the race determines the answer to each external change, and each answer writes a new sentence in the history of the race. Having no diverse structures, the unicellular organism needs no nervous system.

Among multicellular organisms, many are composed of cells which are alike in physiological activities. Great colonies of bacteria, molds, algæ, or certain organisms of different races, may live together, each cell living its own life. The cells may be all of a kind, or they may be alike in function, or they may be of different kinds, and live together in symbiosis. In such cases each cell lives its own life, answers the demands of its own environment, secures its own foods and uses the energy therefrom in its own way, reproduces itself, and perhaps may ultimately die from the lack of water, or food, or oxygen, or other requirements of life. These structures have no nervous system, and need none. Having no diverse structures, no method of unification is required.

Among some molds and bacteria, as well as in other types of life, there may be found diverse structures with no nervous systems. The occurrence of spores, the formation of structures especially adapted to the reproduction of the species, display the beginnings of specialization. The volvox, for example, has upon its outer aspect cells which are in contact with the environment of the individual, and these are concerned with the so-called vegetative functions of the individual. The cells centrally placed are not in contact with the environmental food supply, and these are concerned with reproduction. The external or vegetative cells act according to their environment, which is the environment of the individual; the central or reproductive cells act according to their environment, which is made in part of the vegetative cells and in part of the fluids which bathe them, until the dissolution of the colony sets all the cells free, and the reproductive cells begin the formation of the new individual. Thus, even in organisms of a certain degree of complexity, the reaction of individual cells to the environment of individual cells is sufficient for the maintenance of life.

Plants of even greater complexity of structure may live very long lives without any appearance of a nervous system. Here, also, the cells act as units, each making its own reply to its own environment. The effects of the environmental changes upon the external cells, or of one cell upon its neighbor, of the circulating fluids upon the different cells, are sufficient to initiate those metabolic changes needful to the preservation of the individual and the race. Unity of activity is secured only through the unity of the different structures, and the unity of the forces of osmosis, gravity, and the like, acting upon the entire plant.

With the greater differentiation of parts characteristic of the more complex animals, with their larger bodies, capable of motion, bulky and awkward as they are compared to the simpler animals, the reactions produced in the surface cells by the environmental conditions become altogether inefficient. If an individual is to retain the power of replying efficiently to the surrounding changes—and this is the essence of life—it must act as a unit, even though it be composed of millions of different cells, and even though it be capable of any one of hundreds of different responses. It is in meeting this demand for unity of action that the nervous system is found in function. The only function of the sensory organs is to translate the environmental changes into the language of nerve impulses; the only function of the motor mechanism is to translate nerve impulses into the language of action. The function of the neurons of the ganglia of invertebrates and of the ganglia and central nervous system of vertebrates is to relate the incoming and the outgoing impulses in such a way as best to conserve the requirements of the individual and his kind.

The sea anemone is rather a simple animal, yet it has a better nervous system than many other animals. In the sea anemone the food is secured through the contraction of tentacles which surround the oral aperture. The stimulation of the surface of any one of its tentacles by particles which may or may not be of food value causes the contraction of almost or quite the entire ring of tentacles. It is evident that the contraction of the single tentacle stimulated would rarely entangle the prey. The tentacles must act as a unit, in answer to a single stimulus at one point. The unity of action is secured through the activity of a ring of nervous ganglia around the oral aperture, which transmits the stimulation received by one tentacle to the muscles of all the tentacles. Only in the unified activity of the tentacles can life be preserved.

The beginnings of structures specialized for the performance of nervous functions are found among sponges. These have retractile processes, whose manner of action resembles muscle activity to a certain extent. At the origin of each of these processes lie one or more stellate cells, resembling nerve cells, which send a prolongation into the retractile process. Stimulation of the stellate cell causes the retraction of one or more of the processes, and stimulation of the process itself may cause retraction. The stellate cells have irregular prolongations, which are shorter and seem to be more or less closely intermingled.

The hydra has a double ring of nerve fibers around the periphery of the bell of the animal, which are associated with the muscles and also with the ectodermal cells. Within this ring of fibers nerve cells are placed. The processes of the nerve cells are intermingled, so that nerve impulses probably are transmitted with facility.

In the flat worms a structure resembling a brain appears. This resemblance is only superficial, and there is no homology between the invertebrate ganglia and the vertebrate brain, except as all nervous structures present a certain homology with all other nervous structures. A large ganglion lies near the head end of the body of the flat worm, and two cords of nerve fibers with small ganglia scattered throughout their length extend through the body.

Nerve cells lie scattered among the cells of the ectoderm, and these are sensory in function. The fibers from these sensory cells are intermingled with the fibers from the ganglia. This peripheral position of sensory cells is found among vertebrates only in the olfactory region of the nasal mucous membrane.

FUNCTION OF THE NERVOUS SYSTEM

The earth worm has two ganglia placed at the head end, above the pharynx, and from these pass two gangliated cords. The ganglia are placed segmentally, and are more or less independent. The earth worms studied by Darwin took the sharp bilobed leaves of the Scotch fir by the united broad base, and thus were able to use them without harm from the sharp points. This humble animal is thus cited as indicative of a certain degree of mentality among the lower animals. It is a little difficult to see that this habit is more indicative of mentality than is the activity of certain unicellular organisms, which, meeting any obstruction, usually turn to the right, but which, meeting further obstructions for a number of times, finally turn to the left.

The nervous systems of invertebrates in general present modifications of this general structure. There is usually a large cephalic ganglion or a pair of ganglia, which may be apparently formed from the fusion of two or more ganglia. From the cephalic ganglion or ganglia nervous cords, containing ganglia scattered among the fibers, pass through the length of the body. The sense organs present a few resemblances to the vertebrate sense organs, but they present more striking differences. It is not possible even to say what specific energy of sensation is carried by certain invertebrate sense organs. The gangliated cord is usually more or less completely segmented, and the various ganglia may act more or less independently. The invertebrate nervous system seems to perform the same functions which are performed by the vertebrate nervous system. The nerve cells of invertebrates show about the same evidences of fatigue, the accumulation of chromophilic masses resembling the tigroid substance, and pigment granules like those found in the vertebrate cell, as yellow pigment. Invertebrate nerve cells are much alike through all the different ganglia. The sensory cells placed among the epithelium present a few differences, but the nerve cells of the invertebrates do not show anything like the variations of structure which vertebrates possess.

The same invariable function is present throughout, the unification of diverse structures.

The ultimate source of energy for all living structures is found in changes in their surroundings. Among lower forms of life this statement simply means that foodstuffs, oxygen, water, etc., must be supplied to each cell upon the surface of the organism. Each cell uses these materials for its own metabolic needs, and casts the wastes away into that same surrounding medium. The individual cells of higher organisms are subject to the same need of a constantly-renewed food supply, and of a constant removal of the wastes of metabolism. Currents of water supply these needs among the simpler types of living beings, currents of sap supply the same needs of vegetable cells, currents of blood and lymph supply the same needs among the higher animals. Organisms may move toward the food, probably impelled thereto by chemotaxis or the tropisms. No nervous system is needed for this answer of each cell to the changes in its own surroundings.

Animals of yet greater complexity, having nervous systems of more value, seek food, water and other needfuls with every appearance of forethought. This appearance of forethought, of purposive reaction, is due to the coördinating activity of the nervous system. The "bridges of protoplasm" carry the stimulation derived from the needs of the deeper tissues to the muscles concerned in the movements of the body; they carry the stimulation derived from the presence of stuffs fit for food to the structures capable of catching and eating and digesting that food. These same bridges of protoplasm enable the animal to travel in search of food and of other requirements, thus greatly increasing the available sources of energy. Thus the need of food impels the muscles to increased activity, though this increase in the activity of the muscles must increase its own waste and its own danger from starvation.

The unity of the individual with his racial history has not always a beneficent effect. The perpetuation of the racial instincts, through the intermediation of the nervous system, may perpetuate death rather than life to many of the individuals of the race. As one instance of this tragical repetition of racial history the flight of the white butterflies may be considered. From a headland on the coast of New Zealand every year hundreds of butterflies wing their endless way out over the sea. They fly endlessly, die of fatigue, and drop into the waves. It is supposed the habit is a survival of the habits of ancestors who found an island somewhat farther north, to which they retreated for the summer. But history knows no such island. It must be that some racial history is perpetuated in this fearful and suicidal journey. The flight of the butterflies has been made the subject of much beautiful writing, but no poem ever written of that flight can even faintly shadow the grandeur of the lesson it shows, the absolute, essential and unquestioning unity of the individual with his race.

Animals with well-developed nervous systems are able to unify their activities according to the demands of the year. Squirrels store nuts, other animals store other foods, so that the animal of to-day's plenty reacts to the environment according to the needs of the winter's scarcity. Through the intermediation of the nervous system the animal unifies its summer's work with its winter's hunger.

Animals build nests. Animals with well-developed nervous systems make provisions for the young whom they have never seen. Birds in captivity, hatched in an incubator, still build nests, though no other bird, not even a mate, is to be found. Instincts are preserved through the activity of the nervous system, and thus animals react to their present environment according to the needs of the race. Thus the race is unified in needs and in action. The building of homes or nests, the storing of supplies for future needs, the building of dams by beavers, the migration of birds, seals and other animals, are instances of the manner in which organisms are unified in time. Only animals with well-developed nervous systems keep such complex instincts from generation to generation. Whether the custom of making provision for the future is actuated by conscious forethought or not, the fact that such customs prevail enables the animal of the year to react to the environment of the year, the individual of the race to react to the needs of the race. The nervous system, guided by the forces which perpetuate wise reactions, unifies the individual with the environment of the race through wide changes of time.

Animals with no nervous systems, and those whose reactions are inefficient, are unable to avoid danger, either for themselves or for their neighbors. Animals with well-developed nervous systems avoid danger in many ways. Many animals run from the object feared. This activity is secured through the activity of the nervous system. Others erect the exoskeleton and assume a frightful appearance. This reaction is secured through nervous activity. Others pass into a condition resembling hypnotism, in which apparently all motion becomes impossible. This is secured through the action of the higher nerve cells inhibiting the action of the lower centers. Such animals are said to "feign" death in order that they may escape the attack of other animals which refuse food already dead. The reaction enables others to remain unnoticed by their enemies. In many instances the reactions characteristic of fright have for their purpose the salvation of other individuals of the race. The "lame" mother quail is a familiar object to most country children.

The "lameness" disappears with remarkable celerity when the pursuer has been enticed away from the nest or the young; that is, when the inhibitions of the higher centers are exhausted. The various calls of different animals in the presence of danger serve the same purpose, the protection of other individuals of the same race. Thus, in securing safety, the animal is enabled to act according to the needs of the whole race — the animal is unified in danger and in safety through nerve activity.

In the presence of injury to any part of the body, repair is often facilitated through reflex action. The overactivity of the heart muscle leads to the reflex lowering of blood pressure, and thus to the relief of the heart. The taking of foods of a certain character leads to the increase of the enzymes for the digestion of that class of foods. The presence of the fatigue toxins leads to the decreased activity of the nervous system, and thus to the rest of the body. Pain in any joint leads to the inhibition of the muscles moving that joint. In deficient light the pupils are dilated, in excessive light they are contracted. The ear is partly preserved from injury through the activity of the intrinsic muscles of the ear. The phenomena of inflammation, secured in the most efficient activity through the intermediation of the nervous reflexes, lead to repair and recovery.

All of these reactions are for the good of the individual and the preservation of his life, as a rule. Each may be a source of danger under certain conditions. If it should be granted that under certain conditions the maintenance of the life of an individual is secured at too great a cost, then the biological relationships are apparent. When the reaction to abnormal conditions becomes inefficient, then these same reactions make for the speedy destruction of the individual, and the race is saved from the perpetuation of the unfit. As a result of the reactions, when they are efficient, the safety of the individual is secured; by the same reactions, when they are unable to save the individual, the race is preserved. The efforts toward adaptation cease only with the death of the individual. The race is thus unified in injury, disease, and the forces which make for increased powers of adaptation and repair.

Far more than among animals, mankind is unified in time. The man provides not only for the year's needs, but for the needs of himself and his family for many years. The organized man, through governments, provides for the needs of the people for many generations ahead. The destruction of the forests, the provisions for reforestation, the building of highways, of canals, of parks and playgrounds, all are proofs of the function of the nervous system in unifying the activities of individuals in accordance with the needs of others, though these others may be separated by generations from those who plan for their well-being.

Through the action of associative memory man is unified in his own experiences. The teachings of childhood modify the actions of the old man, and through his teachings, in turn, modify the actions of others. Teachings which are shown to be wise are thus perpetuated without the need for the long processes of racial development through the activities of the nervous system of man.

Through the processes of associative memory, also, the experiences of others may modify the reactions of any individual. By means of language, itself a manifestation of nerve activity, the individual is enabled to be unified with his fellows in experiences. Thus each person who is associated with others may gain from his neighbors the wisdom which may enable him to react to his environment in a much more efficient manner than would be possible if only personal experiences were able to modify his actions.

Through the use of the written language and other expressions of men of ancient times the person of to-day is able to react to the environment of to-day with a wisdom gained from the experiences of all the past ages. By means of history, the experiences of the past may make to-day's reactions better adapted to the good of the individual and his race.

By means of associative memory, and by the use of the neurons concerned in variously relating the elements of experiences, the individual is enabled to modify his reactions in accordance with the future, as he imagines it. He is able to foresee the effects of causes, and thus to modify to-day's activities in such a manner as to prevent those disasters which perhaps never have been experienced, either by himself or by others. The ills never experienced may be avoided only through the activity of associative memory, the power of dissociating and recombining the elements of experience.

Through the action of associative memory, also, the sharing of the experiences of others is made possible. This is true not only in securing the benefits of the experience of others, but also in sharing their troubles. As the activity of the nervous system secures a certain degree of adaptation and compensation in the presence of bodily injury or disease, so in the disease, or pain, or injury of members of the race, by means of the cerebral activities one person shares the pain and makes whatever reparation is possible when any suffer. This unity of the race in suffering is seen most notably in the presence of great disasters. How long after the San Francisco disaster before offers of help were received? How long after the Galveston flood, of the Johnstown flood, or the eruption of Mount Pelee before help was on its way to the sufferers? How long after any suffering is brought clearly before any really humane person before assistance is given? Only when there is a lack of the clear vision is there any delay. The altruistic feeling and action represents the highest and most perfect development of the nervous system. By this means the race is unified in its needs and in its resources.

True, this unification fails at times. Always the failure is due to the lack of the normal activities of the nervous system in its activities. Many ills of others are unknown to us; it is for us to develop the power of seeing more clearly. Many times the means of communication are faulty. Since means of communication can result only from the use of natural resources by the powers of the cerebral cortex in activity, the lack of exact knowledge of one's fellow man can be only due to the fact that not yet have the associative processes reached their fullest development.

Some years ago there was a famine in India. This story is told of that famine. We of America were sufficiently developed and altruistic to try to send food to the sufferers. We sent a shipload of corn. Corn is good food — for us. Unfortunately, the famine-stricken people were not acquainted with corn; they did not know how to cook it, did not like it, and a great part of the corn was wasted or thrown away. Our altruism, our feeling of unity, was sufficient to impel the aid, but the unifying process failed to make that aid efficient, because of our ignorance of real conditions. Also, they were unable to appreciate the value of the food sent, because they had been so long set apart, and were thus so poorly at one with the rest of the world, that they were permitted to die of starvation. More complete knowledge, more complete "sympathy" in the literal sense, would have been possible only through more efficient activity of the cortical neurons.

Only through the unification of the race in the truest sense can the saying reach its fullest truth: "He hath made of one blood all the nations of the earth."

Through the activity of the nervous system the race is unified in inheritance. Among animals, only those traits are perpetuated which are characteristic of individuals of at least a certain degree of fecundity. Among savages the statement is almost as true. The more highly developed the race, the less is the inheritance of race limited by the fecundity of the people possessing the highest characteristics. Among people who think most and think best, the best thought is the thought of all. Teachers are often childless, yet they modify the thought of the next generation in a way which few parents even think of. Childless men plan playgrounds and parks, model tenements and schools, and all that makes for governmental betterment. Childless women teach children and their mothers, provide better conditions for the physical and the mental development of children now living and their children's children. And while to-morrow's children must be born of to-day's physically-fit parents, yet they inherit to-day's strongest thought, though it be the thought of the childless; and their environment is planned by to-day's loving forethought, though it be the forethought of the childless. Civilization at its best is a function of the nervous system by means of which the race is unified in its needs, in its labors, in its powers and in its inheritance.

The ultimate source of energy is found in the environment of the body. Through the activity of the nervous system in governing the body's use of the energy so derived other sources of energy may be discovered. Among mankind this power is developed highly. The sensory impulses are employed more and more efficiently in the use of the various sources of energy with which the world abounds. This use of natural forces is possible only in the presence of a nervous system of great complexity and efficient function.

So far as the nerves of common sensation are concerned, the environment of the body is of the same size as the skin of the body. By means of these nerves and the impulses which they carry the body acts as a unit in the use of foods, the activities of the different parts of the body are coördinated, certain dangers are avoided, and the body is protected from certain abuses, as of overwork, etc. In injury or disease the body is enabled to recover or to adapt itself to a surprising amount of abnormal conditions. By means of motion the knowledge of one's environment may be considerably increased merely by the use of the common sensations. Through pain the individual is enabled to guard against injury; through taste and smell he is able to provide against suffocation and poisoning under certain conditions. Through smell, also, one is able to secure a certain amount of information. Yet the best possible use of these sensations alone must leave the person with a very poor knowledge of a very small world.

The sense of hearing increases the environment to a considerable degree. By means of this sense the individual is enabled to react to an environment which is limited only by his acuteness. Through the action of the association cells and the memories stored and interpreted in them the sense of hearing may become a source of information, a source of energy and of wisdom in the determination of reactions, whose value is scarcely to be estimated. Through this sense, too, the experiences of other individuals become immediately and frequently available. This sense is a very valuable agent in increasing the possibilities of unification of individuals.

The sense of sight probably adds greater size to the human environment than does hearing. By means of sight the environment of the educated individual reaches to the limits of the universe as seen with the largest telescope, on the one hand, and to the limits of microscopic vision on the other. Even if one's experience with these instruments be limited, the experiences of others may be imposed upon a comparatively scanty personal experience by means of the powers of associative memory. Thus the educational value of the experiences of others may serve to add efficiency, and unity, and wisdom to the reactions of any one whose nervous system is capable of delicate perceptions, clear mental visions and wide associational processes. The mental outlook of an ignorant man may be broadened by the beauty of the nightly sky; but as he sees more and more clearly the relation of stars and planets, of meteors and comets, his mental horizon becomes proportionately broadened. Acted upon by the broader environment, he reacts to broader environment. This is the essence of what is called nobility in life and character.

This is the meaning of education in the widest sense, that the sensory nerves be made more and more delicate, so that constantly-decreasing environmental changes may initiate constantly-increasing knowledge and delicacy of reaction; that the associational processes may become constantly more complex in interpretation, and then, through understanding, constantly more simple in significance; that the balance between the facts of to-day's environmental variations may be interpreted more wisely in to-day's answer; that all experiences may be present in increasing vividness in consciousness, so that to-day's reactions may make for the best good of the individual and his race through all of the to-morrows. Thus education lessens self-seeking and narrow seeing; it shows the great, and real, and permanent good rather than the narrow, and transient, and individual gain.

Through the activity of the associational neurons the facts of daily experience are quickly and correctly classified. By means of this reaction the sensory impulses are made to yield the greatest possible energy value and knowledge value. In this way, by the constant classification of facts as they present themselves, the ultimate reaction, the ultimate expression of judgment, is more suitable to the daily demands, better adapted to the real value and meaning of life, and better fitted to conserve the best interests of the individual and his kind. The individual who thus classifies his experiences, who makes best use of the facts as they present themselves to himself personally and to himself through the experiences of others, makes the wisest judgment, the most forceful reactions, and lives the longest, strongest and finest life. Be he "butcher or baker or candlestick maker," or "doctor, lawyer, merchant, chief," he is of the best and happiest; though he may not become famous, he is sure to be fameworthy.

Unicellular organisms make very slight reply to the changes which occur in their surroundings. If these changes are not very pronounced, they may be able to live for a time, or even indefinitely. If the changes are more pronounced, they may adapt themselves to the variation, and yet maintain life. This is seen in certain lake shores of the Western mountains and plains, where slowly-changing saltiness of water has been for ages associated with slowly-changing characteristics of the living organisms which live therein. Among plants, also, no great reply is made to environmental changes, save the changes which the plant itself undergoes in order to maintain its life in the presence of those changes which occur in climate, food, water, etc. Under the influence of the developing nervous system, the reply which is made to an adverse environment may modify the environment. Animals of comparatively simple structure build homes, thus varying the environment of their own bodies, and providing a suitable environment for their young. Animals of greater complexity, with more efficient nervous systems, build more efficiently and provide more suitably for the future. These reactions, when they are controlled by the inherited and tropism-guided nervous system, set temporary circumstances aside, and act without regard to those conditions not present with their ancestors. An instance of this is shown in a report of the life of a beaver, captured when very young, and kept for a time in an office in a skyscraper. At the proper time he built dams of the books, footstools and other small articles in the room, which was, of course, placed hundreds of feet above water mark.

Mankind, in whom the action of the nervous system is associated with consciousness, gives more forceful answer to his environmental changes. Should the factors of the environment affect him adversely, he simply changes the environment. Not only does he adapt his metabolic processes in such a manner as to become able to withstand those changes, as do animals and plants, but he builds larger homes, warms them with fire, provides thicker clothing, makes ice for hot weather, compels artificial breezes with an electric fan, plants trees to modify the winds and the rainfall, levels hills, fills valleys, tunnels mountains, digs canals, dredges rivers and harbors, and in a thousand ways he changes the very face of the earth. He projects his own personality into the inanimate world. To the man guided by the normally active nervous system the forces of nature lengthen his arm, strengthen his muscles, convey his judgments and his dicta to the most distant countries; the whole worldful of inanimate force is simply an instrument for the expression of his own personality. Through the agency of the nervous system the will of man is unified with the forces of the universe.

All these things are only the beginning. What has been achieved is only a foundation for the future's building. The unification of the race is not complete; it is only beginning to become complete. The forces of nature are not yet subjugated. We still crawl on the surface of the earth; we still get in one another's way. Even yet we misunderstand, and quarrel, and go to war. Even yet we often fail to give the danger signal when we see impending harm. Even yet we pretend and imitate, see falsely, and act according to the demands of a mean and narrow environment. Human eyes must be opened more widely, ears must be tuned more keenly, association processes must be more delicately coördinated and adapted to wider environments and more forceful reactions. Future wisdom based upon more wholesome nervous activities must break down the barriers of ignorance, and narrowness, and injustice, until a unified humanity lives fully and rejoices in a universe of subjugated power.

CHAPTER II

THE DEVELOPMENT OF THE HEMISPHERES

The phylogenetic development of the hemispheres presents a series of puzzles. In man there seems no reason to doubt that the functional activity of the cortical neurons is essential to the occurrence of consciousness, as the term is usually understood. If any consciousness is possible otherwise, it must be of a character totally different from the phenomenon now recognized physiologically as consciousness. This possibility may be omitted from a physiological discussion.

Consciousness of Animals

Among animals who have only poorly-developed cortical relationships, or in whom the cerebral hemispheres are entirely lacking, the question of the existence of consciousness becomes impossible of reply. As Huxley said: "The only way to determine how a crayfish feels is to become a crayfish." It is not possible for us to say, for surely, that any creature other than man possesses consciousness in the sense in which we possess consciousness. There is no doubt that many animals act as people act who are supposed to be conscious of their actions, and of themselves as performing those actions; yet it must be remembered that many of our own reactions, ordinarily supposed to be indicative of the most vivid consciousness, are often performed unconsciously and involuntarily. To assume the existence of some other form of consciousness, which is not aware — in other words, is not conscious — adds new complications to the problem and explains nothing. The most satisfactory thing to do in this regard is simply to acknowledge the fact that we do not know how much of consciousness is possessed by animals, and to employ whatever methods we have available to study the matter. Until more facts are presented, any theorizing must be valueless. We may, however, study the phylogeny of the brain structure with a certain degree of profit.

Phylogeny of Cerebral Functions

Among animals in the vertebrate series the development of the cerebral hemispheres goes hand in hand with the development of reactions more and more adapted to the needs of the particular individual in the midst of a particular environment, rather than to the needs of one of a class in answer to the demands of an unvarying environment. The development of the cerebral hemispheres provides the structural possibilities for a great number of potential reactions in answer to any environmental demand. Thus, the possibility of individuality in the various activities of the individuals of any group of animals becomes fixed. Another result of the development of the cerebral hemispheres is found in increasing speed of reply to environmental variations. Variations in environmental conditions affect the life history of brainless animals chiefly or only through varying them, as a race, in perpetuating those individuals capable of making adequate reactions to those changes. But among animals whose cerebral hemispheres are well developed, each individual is capable of making at least a partially adequate reply to new environmental demands.

Many apparent exceptions to these statements are to be found, but they are probably only apparent. It is not easy to devise methods for the measure of cerebral development.

This difficulty increases when a study is made of animals of about the same biological status, or when an attempt is made to determine a structural foundation for racial peculiarities, or for variations in the characteristics of different persons of the same nation or family. It is extremely difficult to find satisfactory methods for the measurement of the respective degrees of development of the various parts of the hemispheres.

Phylogeny of the Cortex

The phylogenetic development of the cortical centers is rather complex. It is not the purpose of this chapter to give any technical discussion of the relations between the brains of the classes of vertebrates, except as these differences may throw some light upon the development of the structures concerned with the phenomena of consciousness.

In the lowest vertebrates, such as amphioxus, there is no brain, in the ordinary sense of the term. The nervous system consists of a tube, with nerve cells and short nerve fibers. The sensory nerve cells are placed upon the roots of the nerves, as in the higher vertebrates, though the migration of the nerve cells in embryonic development suggests the possibility of a primitive type of vertebrate in whom the nerve cells all lie within the walls of the neural tube.

In cyclostomes the brain, such as it is, is composed chiefly of the higher olfactory neurons. There is found a layer of cells like epithelium, which forms a sort of anlage of the pallium. Between the amphioxus and the cyclostome are found no intermediate types. The phylogenetic history of the cerebrum thus lacks several chapters at the very beginning. The condition of the thin and non-nervous pallial fold of the cyclostome brain is duplicated in the folding of the walls of the brain vesicles in the development of the choroid plexus.

The pallium of the cyclostome is composed only of a thin layer of non-nervous matter. The brain of this fish consists chiefly of the olfactory lobes and the connections of the olfactory tracts. The nuclei associated with the olfactory apparatus in the higher mammals are found fairly well represented among the cyclostomes. The cortical centers of olfaction are, of course, not found, since no nerve cells are found in the pallium. The nervus terminalis is represented slightly in the lamina terminalis of these brains, but this connection is not found among the fishes of higher development. It is possible that this relationship of the nervus terminalis may represent the beginning of a cortical somesthetic area. Further study is needed in this matter.

The Archipallium

In selachians there is found a beginning of cortical structure in the olfactory cortex, or archipallium. This center is closely associated with the centers of the thalamus and striatum, both of which are developed among fishes. In ganoids and bony fishes the olfactory areas alone seem to be functional among the parts of the nervous system comparable to a cerebral cortex.

The amphibians and reptiles show a cerebral development which appears to be much greater than is found among the fishes. This might be supposed to underlie a wider cortical representation of the bodily sensations and activities than are possible among the fishes, but this seems not to be the case. The increasing complexity of the reptilian and amphibian brain apparently merely gives opportunity for greater complexity of the relations of the higher olfactory centers.

Apparently very suddenly, among lower mammals, there is to be found the beginning of a neopallium. The archipallium is pushed toward the lateral and posterior region of the cortex, while the relationships of the olfactory centers remain practically unchanged.

DEVELOPMENT OF THE HEMISPHERES

The Rhinencephalon

The entire olfactory nervous apparatus is unique in its retention of its primitive relationships through all the extremely marked variations of the other nerve centers. The neopallium presents a succession of developmental changes during phylogenetic and ontogenetic progress, but the archipallium presents only those variations imposed upon it by the pressure and interposition of other centers and tracts. This conservatism of the olfactory centers, if the rather figurative term may be so used, compares with the physiological relationships of the rhinencephalon among higher animals and mankind.

Olfactory centers lie in close relationship to all cortical centers, and these are related very intimately to the basal centers. Thus, it is found in man that, while consciousness of things smelled is not usually very vivid, unless the stimulation is very pronounced, the reactions governed, either directly or indirectly, by the olfactory impulses are decided, involuntary, energetic, and associated with many emotional and instinctive phenomena. The power of the olfactory stimuli to arouse memories of notable vividness is dependent, in part, upon the intimacy of the relationship of the olfactory centers to the centers concerned in the reception and memories of other sensory impulses.

In monotremes the olfactory relationships are practically the same as in reptiles and amphibia. Here the lateral and the posterior cortical areas are not concerned with the reception and coördination of olfactory impulses, but begin to assume the place of a somatic pallium. No reports are available concerning the experimental stimulation of the cortical centers in these animals, but the structural relations are somewhat similar to those of the higher mammals. The olfactory centers are even more highly developed than in non-mammals.

The anterior commissure of marsupials is greatly increased in size, and this is due to the presence of a large number of the commissural fibers, which afterward assume the position of the corpus callosum in higher mammals.

The Corpus Callosum

The increasing development of the corpus callosum appears to be an important factor in the phylogeny of the mammalian brain. This is associated with a relative diminution of the hippocampus. The primitive hippocampal relations are recalled by the "perforating fibers" of the corpus callosum. The interposition and increasing development of the corpus callosum pushes aside and distorts the lamina terminalis in a most complex manner.

The posterior part of the hippocampus becomes more and more complex in structure, while the functional relations to other parts of the nervous system remain practically unchanged.

The Hemispheres

The hemispheres increase in size much more rapidly than does the skull, both during ontogenetic and phylogenetic development. This increase causes the folding which produces the fissures, sulci, convolutions and gyri of the adult human brain. This increasing complexity of the folded surface makes possible a great area of cortical structure, which is associated with increasing complexity of the cell relationships and the cell structure of the cortex.

Functional Development

The functional development of the cerebral cortex is not at all well known. Very few experiments have been reported concerning the effects of stimulation of the various areas of the cortex in the lower mammals, or of the effects of their

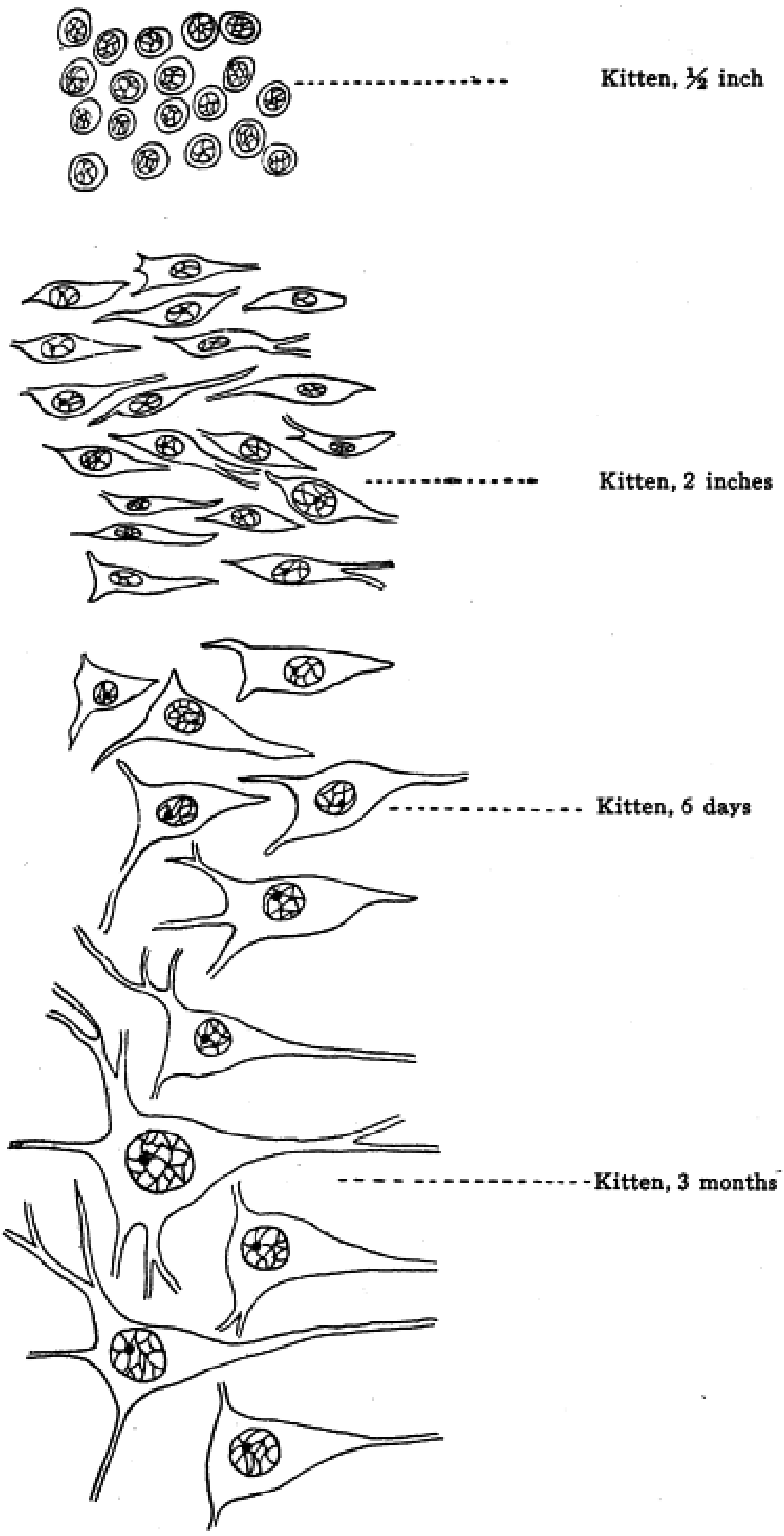

Fig. 1. Cells from cerebral cortex of kittens of different ages, all magnified about 625 diameters. Camera lucida. The cells of the kitten about one-half inch long are almost perfectly round, with large nuclei which occupy almost the entire cell. The cells of the kitten about two inches long show the beginning of the protoplasmic prolongations. At six days after birth the pyramidal cells show the typical form. The kitten of three months shows pyramidal cells which are larger, with longer and more branching dendrites. The pyramidal cells from the cortex of a full-grown cat display no marked variations in form, and very little increase in size. Compare with Fig. 2.

experimental ablation. Studies should be made of the brains of the lower mammals which have been subject to disease or accident, as well as of those subject to laboratory tests. From our meager supply of facts, the following general account may be given, with the understanding that it is, on the whole, very unsatisfactory, and that it must be subject to considerable modification on further study.

The fishes, amphibia, reptiles, and the marsupials react to the changes in their environment through the intermediation of the lower centers; the midbrain, medullary, thalamic and striate centers are sufficient for the coördination of the movements needful for the proper orientation of the individual to his environmental changes. The olfactory impulses, partly, no doubt, because of the anterior position of the olfactory lobes in the animal body, and partly because of the immense importance of the olfactory impulses in the life history of the animals, are represented by centers of constantly-increasing complexity. Interpolated neurons also increase the possibility of more exact reactions, better adapted to the preservation of the life of the animal, both in seeking food and in avoiding danger. Thus, the olfactory impulses have the honor of being represented in the earliest cortical centers.

The nervus terminalis, in the lower fishes, is a tract which passes from the midbrain centers to the lamina terminalis. Its specific energy is not known.

It appears that the visual impulses are next represented in the cortex. The visual area is placed at the posterior pole of the cerebrum, and this position also indicates its comparatively great phylogenetic age.

Land animals begin to need the sense of hearing and also the sense of touch. Touch, in fishes, must be comparatively useless from the biological standpoint, but among land animals it assumes considerable importance. The touch impulses in these animals are carried by the fiber tracts relating the cerebellar centers to the motor apparatus. By the cerebellar connections the visual and auditory impulses, as well as those arising from variations in temperature and the impulses of touch and pain, initiate the proper reaction to environmental changes. The midbrain and interbrain assume, in part, the functions of coördination in the fishes, as well as in the land animals. The development of the cerebellum among land animals is of interest in this connection. Fish and birds, moving in an element of about the specific gravity of their own bodies, need delicately coördinated neuro-muscular apparatus. They have the cerebellar structures well developed.

In the amphibia and reptiles two groups of centers, physiologically distinct, are to be found. The anterior group includes centers which are concerned in the coördination of olfactory impulses, and in facilitating the motor reactions in answer to these. The posterior group includes the centers which are connected in the coördination of all other sensory impulses and the determination of the motor reactions necessary in answer to these impulses.

These two groups remain practically distinct, except for the superseded nervus terminalis in lower fishes, until the mammals are reached. Then the appearance of the neopallium indicates a beginning of a cortical representation of the impulses previously coördinated only by the posterior groups of centers, the midbrain, pons, medulla, cerebellum and cord. The power of giving variable and complex answers to environmental demands is not well developed among non-mammals, or among the lower mammals.

Visual Development

In birds the impulses concerned in relating the movements of the individual to things placed at greater distances become of value in maintaining life. The anterior part of the midbrain, which is concerned in coördinating the visual impulses, attains a marked development. The hemispheres of birds are very small, and there is no reason to believe that there is any cortical representation of sight. The visual impulses act through the corpora bigemina of the midbrain, the floor of the aqueduct, the nuclei of the cranial nerves, the cerebellum, and the spinal centers by way probably of the tecto-spinal tract. The visual impulses are of great importance in controlling the movements of the bird, but this does not indicate whether birds do or do not consciously see and look.

Auditory Development

Auditory impulses are of less importance in birds. The posterior part of the midbrain, which corresponds to the posterior colliculus, is almost lacking. The vestibular impulses are of considerable importance in birds, as in fishes, and for the same reason. The bird, as well as the fish, lives in a medium which has about the same specific gravity as the body of the individual. The movements must be well governed or a loss of equilibrium would result. The vestibulo-spinal tracts, as well as the cerebellar connections of the vestibular nuclei, are of great importance in the proper correlation of the muscular activities which secure motion, the seeking of food, and the flight, by means of which they are enabled to resist being themselves used as food.

It thus appears that the olfactory impulses, first of all, then the visual impulses, became represented upon the cortex. The auditory areas are next developed, functionally as well as structurally. The cortical representation of the common bodily sensations appears to follow, and then the motor cortical centers. The development of the overflow areas is associated with the development of the primary sense areas, and the development of the intermediate and the language centers is attained only in mankind.

Sensori-motor Areas

The sensori-motor areas are not well developed even in dogs and cats. The cruciate sulcus is homologous with the central sulcus, or fissure of Rolando. The cortex upon the anterior aspect of this sulcus is concerned in the control of those movements of the skeletal muscles which are called volitional. The area is related to the lower centers by the tracts called pyramidal. These tracts are very poorly represented in dogs, cats, and animals of about that rank. In monkeys these tracts, as well as the sensori-motor areas, are fairly well represented. In man the sensori-motor area is of great extent; the impulses from this area are of great importance in the life of the individual, and the pyramidal tracts become conspicuous factors in the structure of the spinal cord.

Speech Centers

Anterior to the sensori-motor area is found, in man only, the center for speech. The structure of the cortex of both hemispheres seems to be adapted to the reception and coördination of the impulses concerned in the control of the speech movements, but usually only the left speech center is functional. In persons who use the left hand most, or in whom some accident or disease has destroyed the left center, the corresponding group of cells of the right hemisphere may assume the duties of controlling the speech movements.

Overflow and Intermediate Areas

With the exception of the olfactory cortex, each cortical sensory area is surrounded almost or quite completely by an overflow area. Between the overflow areas lie areas which are variously called intermediate areas, association areas, or vacant, or silent, or non-functional areas. Of all these terms, the first is most logical. Intermediate areas are those lying between the areas of known function. This term gives no false conceptions concerning the functions or relationships of the areas, and does not pave the way for misunderstandings in the future.

In all animals the intermediate areas seem to be almost or quite non-functional. In mammals of quite a fair development the ablation of practically the entire cortex, under favorable conditions, is not followed by any marked loss of nervous functioning. In man practically all of the left hemisphere and almost all of the right hemisphere are apparently capable of development. The development of the cells of the cortex and the progress of the medullation of the cerebral tracts indicate the importance of the integrity of the cortical centers in civilized mankind. It is true that most remarkable injuries of brain substance may be suffered without the appearance of any localizing symptoms. The more highly developed any person is, however, the less is his chance of suffering brain lesions without symptoms.

The impulses primarily reaching any cortical center cause the stimulation of the overflow area adjacent to that center. The physiological conditions of these cells, as well as of the cells in the primary center, become somewhat changed each time the stimulation occurs. The development of the cells of the overflow areas thus results, and they are able to be concerned in the storing of memories.

The Stereognostic Area

The appreciation of the solidity of objects, and of their distance and size, results from the relationship between the visual overflow and the somatic sensory overflow. A center is thus developed in the parietal lobe which is concerned in the correlation of the visual, tactile and muscular images. The extension of areas of developed cells through the overflow areas leads to the structural relationships which underlie

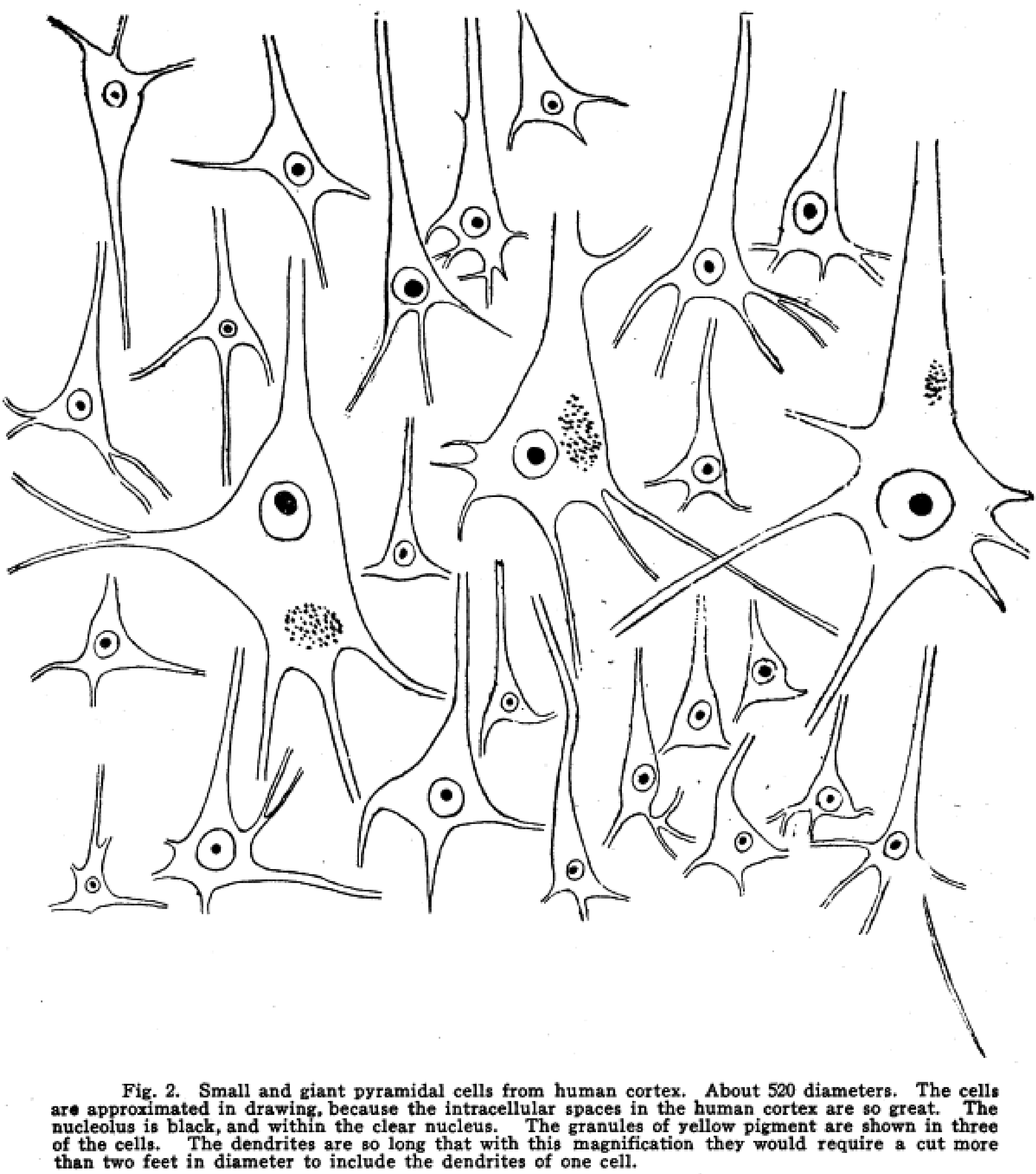

Fig. 2. Small and giant pyramidal cells from human cortex. About 520 diameters. The cells are approximated in drawing, because the intracellular spaces in the human cortex are so great. The nucleolus is black, and within the clear nucleus. The granules of yellow pigment are shown in three of the cells. The dendrites are so long that with this magnification they would require a cut more than two feet in diameter to include the dendrites of one cell.

the classification of ideas, the consideration of the environmental changes from which sensory impulses arise, and the associational functions by means of which any given reaction may be enabled to make proper reply to any number of factors, though these may have stimulated the nerve centers even years before the reaction is given. The phenomena of the activity of the overflow area are, at times at least, associated with the consciousness of thought, choice, effort, etc., and this is the reason why the unfortunate term "psychic" has been employed in this connection.

The Ontogeny of the Cortex

The ontogenetic development of the cerebral cortex is not less complex than the phylogenetic development. Ontogeny repeats phylogeny to a certain extent, though a great many steps of the phylogenetic development are omitted, and other steps are interposed which have no known type in the phylogeny of the nervous system.

The entire nervous system arises from the development of cells originally placed upon the surface of the body. In the embryo the epiblast becomes depressed, the cells multiply rapidly; the depression continues until the ridge of cells becomes imbedded in the mesoblastic tissues of the embryo. The epiblast grows over the deep groove, and the cord of cells is thus shut off from the external surface.

These cells continue to multiply. Certain of them divide in such a manner that of the daughter cells one group retains full power of reproduction, but has little irritability, while another group of daughter cells retains marked irritability, but has no power of reproduction. The cells of the first group are called spongioblasts, and from them develop the neuroglia cells; the other group of cells, neuroblasts, develop into nerve cells. The actual number of nerve cells of the human body is complete before the fifth week of embryonic life. After about that period the cells develop in size, form and function, but they do not increase in numbers. The neuroglia cells retain the power of reproduction throughout life.

Primitive Vesicles

The part of the infolded epiblastic tube which is to form the brain becomes distended unequally so as to form three vesicles. The first and the third of these become constricted into two divisions, thus forming five vesicles. The walls of these five vesicles become developed into the cerebrum, interbrain, midbrain, pons, medulla and cerebellum. The walls of the anterior of these vesicles become developed into the prosencephalon, and it is with the prosencephalon that we are chiefly interested at this time.

The Ventricles

At first a single, rounded vesicle, there soon appears a depression running antero-posteriorly on the upper aspect of the vesicle. This depression continues until a deep fold is produced. The infolding of the wall continues, and the fold is pushed into the cavity of the vesicle, now apparent as the ventricle. The part of the wall which is pushed into the ventricular cavity never assumes any nervous characteristics, and is developed into the epithelial layer of the choroid plexus. Connective tissues supporting blood vessels push into the ventricles with the cell layer just mentioned. The choroid plexus of the adult is thus formed.

The Mantle

The lateral walls of the vesicle become developed into the cortex. The inferior wall becomes greatly thickened, and the cells become developed into the gray matter of the corpus striatum. The fiber tracts which push between these cells complete the formation of the striatum. The optic thalamus is developed in like manner from the walls of the second vesicle.

The Lateral Fissure

At about the fifth week, in the human embryo, there appears a sulcus or fissure caused by the infolding of the cortex. This deepens and produces an indentation in the ventricular wall. This fissure is called the fissure of Sylvius, or the lateral fissure of the cerebrum. The infolding is continued until a part of the cortex becomes completely covered from view. The outer fold of the cortex is called the operculum; the part which is folded within is called the insula, or the island of Reil.

Cortical Foldings

At a later time during intrauterine and extrauterine life the infoldings of the cortex continue, and these increase in length, complexity and depth for a number of years, probably until maturity, and perhaps longer. It is probable that the development of individual nerve cells continues throughout life, though no new cells are produced.

Histogenesis of the Lower Neurons

The cells of the nervous system are all alike at the time when the formation of the neuroblasts is complete. The cells then are round, with large, deeply-staining nuclei, and a thin layer of protoplasm of feeble staining power investing the nuclei about equally on all sides. In a ten-weeks' human embryo the cells in the different parts of the nervous system are fairly well differentiated. The cells of the medullary centers are largest and most highly developed. Those of the centers

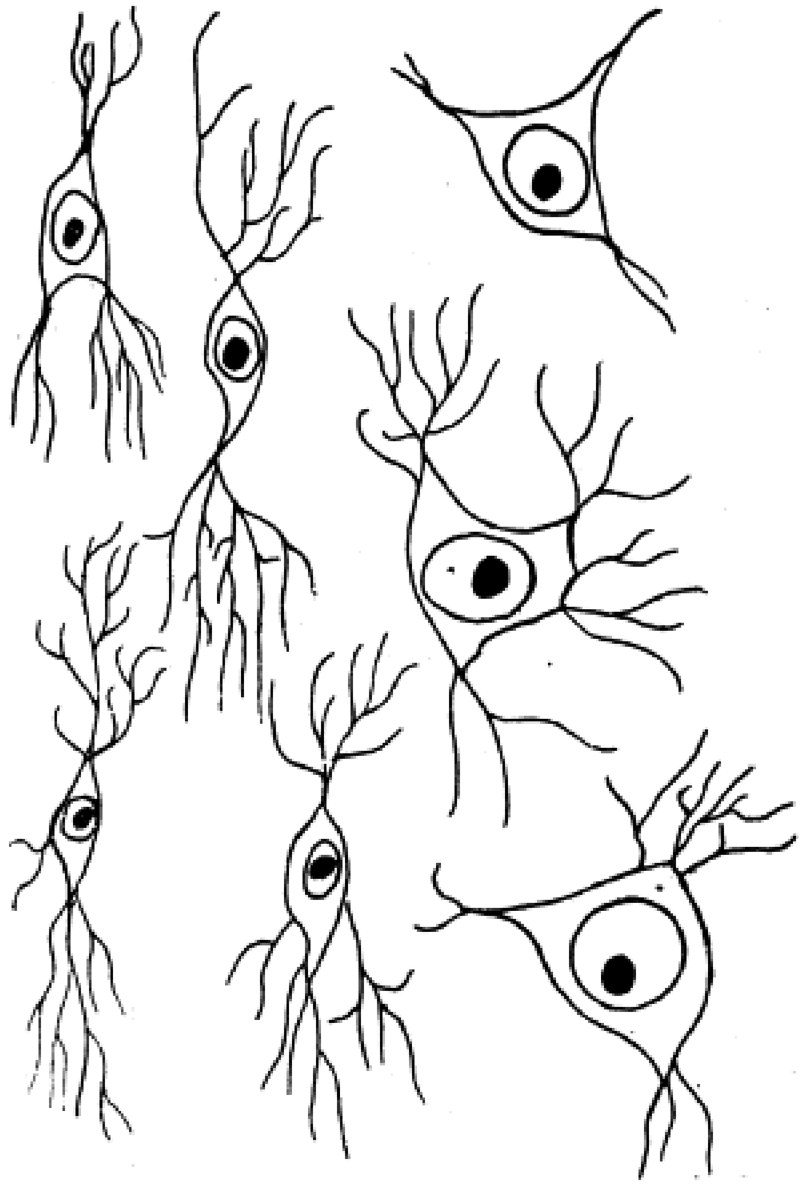

Fig. 3. Spindle and polymorphic cells from the external layer of the human cortex. These cells are not frequently found in the brains of lower animals, nor in the brains of idiots. They are poorly developed in young children, and are most plentiful and best developed in the overflow areas of the adult human cortex. They are also plentifully found in the olfactory cortex.

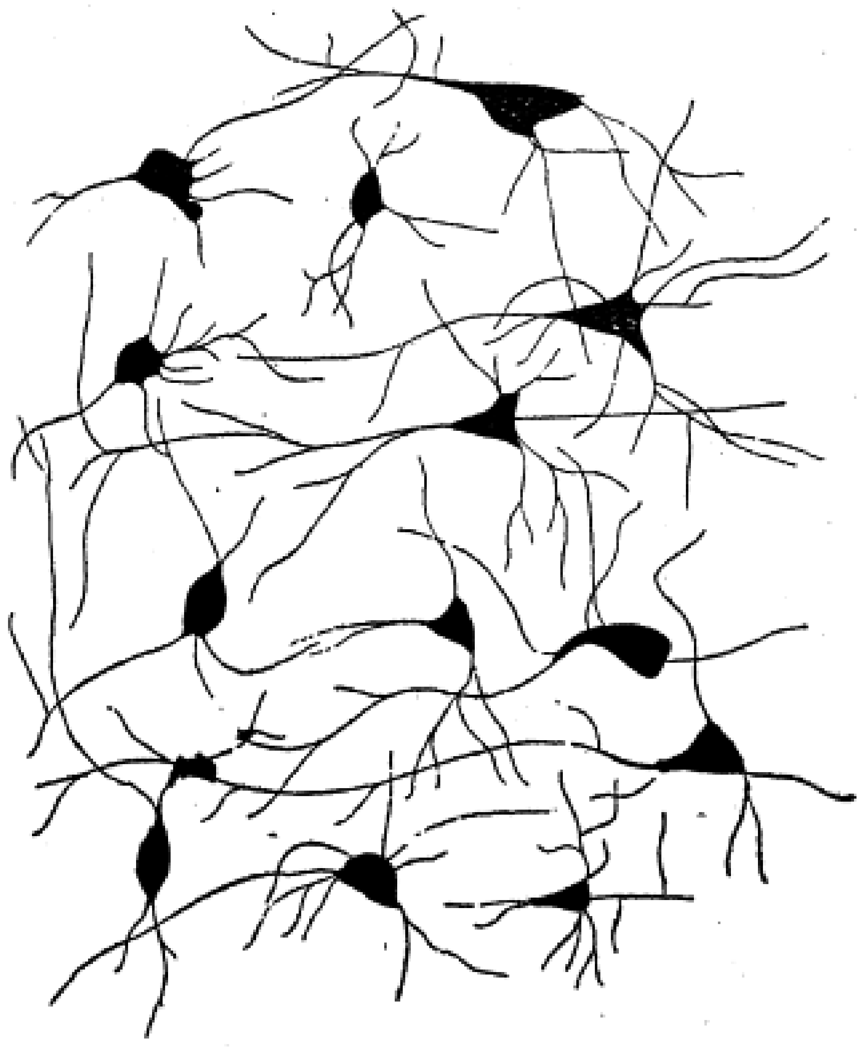

Fig. 4. Cells from the cortex of the rabbit's brain. 380 diameters. The irregular appearance of the pyramidal cells and the short dendrites should be noted.

of the midbrain and pons are almost as large. The cells of the spinal cord are becoming arranged in groups, not yet very well defined. The development of the lower part of the cord is less complete than the upper part. The cells of the sensory ganglia can be seen in the intervertebral foramina. The cells of the cerebral cortex are only barely beginning to become differentiated. It is very difficult to distinguish the nerve cells from the neuroglia. Some of the nerve cells show beginning outgrowths, but these are very small, and are not easily distinguished on account of their feeble staining qualities. (Figs. 1, 2.)

From the tenth week to the fifth month the change in the size of cortical neurons is less apparent than is the increase in size of the cells of the lower centers. The cord and the medullary, pontine and midbrain centers increase greatly both in size and in peculiarities of outline; but the cortical neurons grow slightly in size, and scarcely more in complexity of outline.

Between the fifth month and birth the cortex increases rapidly as a whole and in the size of the cortical cells, in their dendritic and axonic development, and in the assumption of the characteristic staining reactions.

Histogenesis of the Cortical Neurons

The histogenesis of the cortical neurons is of a certain interest. The cells first to be differentiated as nerve cells are almost or quite perfectly round. The nucleus occupies almost the entire cell body. A single deeply-staining nucleolus is usually present; rarely there are two or three nucleoli. These nucleoli are, at the first, very much alike. Afterward, as development progresses, one nucleolus seems to be present which is of a slightly different type from the others; indeed. the supernumerary nucleoli seem to be only rather large net-knots in the adult neuron. The network of the nucleus of the embryonic neuron is coarse and stains very deeply. The protoplasm is scanty and stains with such great difficulty that it is often impossible to determine its extent. As development proceeds, the protoplasm displays the most pronounced changes from the embryonic type. After attaining a thickness of about five microns around the nucleus (in the human embryo), the protoplasm begins to branch out in one or more directions. Usually two prolongations are to be found, at opposite sides of the nucleus. This is the case with the sensory cells, with the cells of the higher centers, and, for the most part, with the cells of the cortex. In the motor nuclei of the first order, through the whole nervous system, and in the pyramidal cells of the cerebral cortex, there appear at the same time three or more prolongations. The large multipolar cells are sometimes irregular in outline from the first. The more usual form is, however, the bipolar at first, with the various irregularities appearing at a later stage of development.

The bipolar form underlies a physiological attribute of the neuron. Throughout life it receives by one process the impulses which affect its metabolism, and discharges by way of another process the nerve impulses which are initiated by its activity.

In the case of the sensory neurons of the first order the two processes usually approach one another and finally coalesce for a variable distance from the cell body. The multipolar cells send out many, and long, and freely-branching dendrites, which are probably all receptive in function. The emissive prolongation, called in the adult cell the axon, remains single in almost all cells. In the cerebral cortex the cells, which present at first a perfectly undifferentiated appearance, ultimately become developed into several different types, each with its own particular function. Here are found, first, the peculiar cells, either diaxonic or amacrine, which lie along the surface of the cortex. These receive impulses, probably, from all parts of the nervous system. Among these branch the dendrites of the different layers of pyramidal cells, the collaterals from the axons of the cells of the other layers of the cortex of the same area and perhaps other areas, and the axons of the inverted pyramids. These cells are probably those concerned most immediately in consciousness. They are scarcely to be found in the brains of animals, in any well marked development; they are first injured in certain mental diseases; they are not at all well developed in the brains of idiots or imbeciles, and sometimes are found poorly developed in the feeble-minded. The exact place of these superficial cells is not well known. Much more work needs to be done in studying the brains of persons whose mental traits are well known. (Fig. 3.)

The cells which develop into the pyramidal cells show their tendencies almost with their first outgrowths. They send one well-marked prolongation toward the surface, and the triangular appearance of the cell, with a single straight, regular prolongation from the center of the base of the triangle, is very characteristic. These cells afterward assume the function of carrying the nerve impulses away from the area where they are found. The largest of the pyramids carry impulses by the longest axons, and, among the very large pyramids of the motor area, there is reason to suppose that the largest cells are those which send impulses which ultimately reach the largest muscles. This relationship is of interest in connection with certain phenomena associated with the symptoms of mania and melancholia.

The multipolar and polymorphic cells of the cortex are developed from the first in an irregular manner. Cells are found in the lower layers of the embryonic brain (human) which look as if they were intending to grow into pyramidal cells, but in the adult brain no typical pyramidal cells are found in the deeper cortical layer.

Later Development

During the later stages of intrauterine life, and during the life of the individual, the neurons increase constantly in complexity of structure. The number of cells resembling embryonic cells becomes progressively less during early life, and there is some reason to believe that this development of the individual cells continues throughout the entire lifetime. It is certain that there is no age limit to the functional development of the cortical neurons, and the facts of the manner of education among elderly people, together with the manner of assumption of new duties by cells after certain injuries or diseases of the brain, points clearly to the supposition that the functional development is associated with a structural development of the neurons. In other words, education and mental development are associated with a structural and functional change in the cortical neurons.

Ontogenetic Possibilities

Since there are found large numbers of neurons of an embryonic type in the brains of persons who are elderly and whose mentality is supposed of high order, and since there does not seem to be any limit to the development of even very old people from the mental standpoint, it may be concluded that the ontogenetic development of the cerebral cortex is not complete, even under the most favorable circumstances. It is certainly true that there is no age limit to the development of the functions of the cortical neurons.

Phylogenetic Possibilities

It seems true, also, that the phylogenetic development of the cortical neurons is not yet complete. There are yet areas upon the surface of the brain, especially in the right hemisphere, whose function either is not known or which have no function at present. Reasoning from the history of the development of civilization, and the development of the mental characteristics of children, it appears now probable that considerable opportunity for increased complexity of associational processes — that is, for increased intellectuality — remains even yet upon the cortex. Certainly no modern Alexander need weep for more worlds to conquer if he consider mental attainments of any value.

CHAPTER III

CEREBRAL RELATIONS

The cerebral cortex is associated with the other parts of the nervous system by means of systems of fiber tracts which transmit impulses from the lower centers to the cortex, and from the cortex to the lower centers. Other fiber tracts associate the different parts of the cortex with one another.

Isolation of the Cortex

The cerebral cortex is not directly related to the external world. Sensory impulses reaching the cortex have been transmitted by means of at least three different neurons, and it seems probable that most or all of the sensory impulses have been transmitted by a great many more than three neurons. It is not possible to say how much the stimulation received by the sensory neuron of the first order may be changed in thus being handed from one neuron to another on its way to the cerebral cortex. The phenomena of color vision, the temperature sense, pain, etc., seem to indicate that there is not necessarily any qualitative relationship between the characteristics of the external world and the sensations these characteristics initiate in consciousness.

On the other hand, the cortical neurons do not enter into any direct relationship with the motor organs of the body All impulses concerned in controlling the movements of the body are transmitted by at least three different neurons on their way to the muscles, and it is probable that a great many more than three neurons are concerned in the transmission of any motor impulses from the cortex to the muscle concerned.

The isolation of the cortex is complete. Nothing but nerve impulses can bring it into relationship either with the environmental variations or with the instruments of its own activity.

In the cortex are found the layers of neurons thus imprisoned, probably more than a thousand millions in number, each of which lives its own life, performs its own duties, acts in accordance with the algebraic sum of all the impulses reaching it, and as its activity is modified by the variations in the pressure and quality of the blood which supplies its nutrient lymph. Under abnormal conditions the effects of bacterial invasion and various toxic or pressure conditions also affect the neuronic activity. These millions of cortical neurons receive impulses by way of the afferent tracts directly, or from one another by way of the cortical association tracts. The association tracts transmit impulses which must ultimately have been carried to some cortical area by way of the afferent tracts. The cortical areas send impulses by way of the efferent tracts directly, or to other cortical areas by way of the association tracts. The impulses transmitted from one cortical area to another must have their ultimate function in the modification of the impulses transmitted by way of the efferent tracts. The ultimate origin of the impulses concerned in cortical activity must be from the sensory neurons of the first order, and the ultimate destination of the impulses initiated by cortical activity must be the motor neurons of the first order. There are thus to be considered with the cortical relations the tracts which are ascending, tracts which are descending, and association tracts.

Ascending Tracts

The neuron systems of the ascending pathways carry all the impulses reaching the cortex. Upon the impulses carried in this manner rests all the complicated mechanism we are pleased to call the intellectual faculties. These few tracts and nuclei, with their few fibers of infinitesimal delicacy, their few cells of apparently simple structure, transmit all of the impulses which initiate the associational and motor impulses of mankind. All the tremendous superstructure of science, and art, and philosophy, all the notable achievements of mankind through the ages, all the ingenuity which has preserved and translated the history of the past, even through the geological ages, which has weighed and analyzed the stars, outlined the paths of the comets, and subjugated the most powerful forces of nature, has for its foundation only the impulses carried by this apparently inefficient complex of thin white strands of fibers, with a few groups of almost invisible ganglia and nuclei scattered among them.

By means of impulses carried by these paths the history of an individual may be modified, and his activities may, in turn, affect the history of the race for all time. By means of the impulses carried by these tracts to his own brain, the physician is able to determine the needs of his patients, and by means of the motor tracts he may affect the cortical activity of his patient in such a manner as to help him to increased strength and usefulness in the world.

Common Sensory Tracts

The cortical fillet carries the impulses from the common sensory nerves of the entire body to the cortex. It apparently emerges from the thalamus and passes to the cortex, chiefly of the central region. Lesions of the cortical fillet cause anesthesia of the opposite side of the body if complete, or the corresponding part of the body if partial. Hemiataxia occurs at the same time.

The parietal stalk appears the more important. Flechsig's study of this tract has not been modified by later tests. The parietal stalk issues from the optic thalamus upon its lateral aspect. It terminates chiefly by forming synapses with the cells of the cortex in the postcentral gyrus, but some of the fibers pass to the precentral gyrus, and perhaps in part the anterior frontal gyrus and the gyrus cinguli. Flechsig gives the different bundles, arranged according to their time of medullation, as follows:

1. The alpha bundle runs from the globus pallidus to the upper third of the central gyri, chiefly the anterior gyrus. Its function is not known.

2. The beta bundle is a large one. It originates in the posterior part of the lateral nucleus of the optic thalamus and terminates in the upper third of the postcentral gyrus and the adjacent cortex.

3. The gamma bundle is also a large one. It seems to originate in the globus pallidus, but its actual origin is not known. It passes to the upper part of the postcentral gyrus.

4. The delta bundle runs from the lateral nucleus of the thalamus to the middle third of the postcentral gyrus.

5. The eta bundle runs from the anterior part of the lateral nucleus of the thalamus to the lower third of the postcentral gyrus.

6. The zeta bundle runs from the superior part of the lateral nucleus of the thalamus and to the foot of the superior frontal gyrus and the neighboring part of the cingulus.

It seems, from the comparative times of the medullation of these fibers, that the transmission of the impulses from the lower part of the body precedes the transmission of the impulses from the upper part.

Direct Paths

The impulses to the lateral nucleus of the thalamus, and possibly to the globus pallidus, are carried by different pathways. The most direct sensory path is that which includes the sensory neurons of the first order, the fasciculus gracilis or fasciculus cuneatus, the nucleus gracilis or nucleus cuneatus, and the medial fillet to the lateral nucleus of the thalamus.

Indirect Paths

The indirect paths include the sensory neurons of the first order, the dorsal nucleus, the spino-thalamic tract to the lateral nucleus of the thalamus, and the even more complex paths through the cerebellum. These tracts have not been exactly determined, but they are known to include the cerebellar hemispheres, the nucleus dentatus and the red nucleus. Probably the inferior olive and the arcuate nucleus should be included. The brachium conjunctivum carries the impulses from the nucleus dentatus to the red nucleus, and the fibers from the red nucleus join the fillet on their way to the lateral nucleus of the thalamus. The impulses concerned in the sense of touch and the sense of muscular effort are carried by the more direct paths, as well as by the indirect paths. The sense of temperature and the sense of pain are probably carried only by the indirect paths. A certain amount of time is required for the transmission of a nerve impulse from one neuron to another, and this is one reason that a thing may be felt as touching the skin first, then it may be felt as being warm or cold at a time appreciably later.

Auditory Paths

The temporo-thalamic, or auditory, or acustic radiation, as it is variously called, originates in the medial geniculate body, passes posteriorly to the lenticular nucleus, and terminates in the cortex of the superior temporal gyrus. This tract carries auditory impulses. They are transmitted from one neuron to another from the ganglion spirale, the nuclei of insertion of the acustic nerve, the nuclei of the trapezoid body, the superior olive, the lateral fillet and the nucleus of the lateral fillet, the posterior quadrigeminates, the medial geniculate body, and thus to the cortex.

Lesions affecting the acustic radiation cause a partial deafness, which may be more pronounced in the opposite ear, but which involves both ears to a certain extent. This is due to the fact that the acustic pathway is partially crossed.

Visual Paths

The occipital, or optic, or visual radiation, as it is variously called, is composed of fibers which are the axons of cells in the lateral geniculate body and the pulvinar of the thalamus. They pass in the posterior limb of the internal capsule to the lingual and cuneate gyri. This tract carries the impulses which originate in the homolateral halves of both retinæ and the macula lutea of both retinæ. Injury of this tract is followed by loss of vision in the homolateral halves of both retinæ, with a corresponding loss of the contralateral field of vision. Injury of either tract interferes very little with vision in the direct line, since the macula lutea has the double representation in the cortex. Visual impulses are certainly transmitted by five, and probably by many more, neurons before reaching the cortex.

This tract includes some descending fibers, probably the axons of the large pyramidal and stellate cells of the occipital cortex.

Gustatory Paths

The pathways of the impulses concerned in the sensation of taste have not been determined. Even the sensory neurons of the first order concerned in taste are not certainly demonstrated. The clinical evidence is so contradictory that it appears probable that there are considerable individual variations in the manner in which the impulses of taste are carried. Probably the impulses follow the following paths: Sensory neurons of the first order of the fifth, ninth and seventh cranial nerves, the nuclei of insertion of these nerves in the medulla and the solitary nucleus, the lateral fillet, the lateral nucleus of the thalamus, and the thalamic radiations to the cortex of the inferior aspect of the third temporal convolution, the gyrus cinguli, and the fusiform gyrus. Lesions of the cortical gyri mentioned have been found in cases of epilepsy with gustatory auræ, and in cases of parageusia. The determination of the pathway of the impulses concerned in taste is made the more difficult because the taste sensations depend to so great an extent upon the activity of other nerves. The sensibility to taste sensations is modified by the temperature sense, and variations in the vascular conditions of the tongue affect the sensations of taste both quantitatively and, to a certain extent, qualitatively. The fact that olfactory impulses may be interpreted in consciousness as taste sensations affects the validity of the clinic histories as evidence in some cases.

Lesions affecting the vaso-motor nerves to the tongue, or of the sensory impulses upon which the vaso-motor reflexes to the tongue depend, are thus indirectly causes of parageusia and perhaps of ageusia.

Olfactory Paths

The term "ascending" seems subject to criticism when applied to the olfactory tracts, which pass almost horizontally into the brain. The olfactory pathway begins with the olfactory neurons of the first order, which are placed in the olfactory region of the nasal mucous membrane. The olfactory nerves are the axons of these cells, and they pass upward through the cribriform plate and into the olfactory lobes, where they enter into synaptic relationships with the mitral cells. The axons of the mitral cells make up the olfactory tracts, which pass backward to the cerebral hemispheres. They pass by complex paths to the gray matter of the anterior perforated space, septum pellucidum, subcallosal gyrus, gyrus cinguli, fasciola cinerea, fascia dentata, subiculum, hippocampal convolution, amygdala, and uncinate gyrus. Consciousness of olfactory images probably occurs as a result of the activity of the cells of the cortex of the gyrus cinguli and hippocampal gyrus with the neighboring cortical areas, while the other neuron groups mentioned are chiefly concerned with relating the somatic and visceral activities of the body in answer to the olfactory impulses.

Cortical Relations

The impulses carried by the neuron systems of the sensory conduction paths reach the cortex usually about midway of its thickness. In the auditory area the radiating fibers (radiations of Meynert) reach the external layer of the cortex. Elsewhere they terminate in the line of Bailarger, which occupies the area of external large pyramids. These radiating fibers form synapses with the various types of cells of the layers of the parts of the cortex traversed. These include the Golgi Type II cells, the inverted pyramids and small multipolar cells, besides the small, large and medium pyramids. (Figs. 5, 6.) The inverted pyramids send their axons into the external layer of the cortex, the stratum zonale. Here they enter into synaptic relations with the dendrites of the cells of the pyramids of all layers.

First Layer

The cells of the external layer of the cortex, the stratum zonale, are small, stellate or fusiform in outline, and of a structure which has yet to be more fully studied. Cells of this layer are described as having two or three axons which branch freely among the fiber elements of the stratum zonale. If these cells have more than one axon, it is evident that they are capable of transmitting impulses in more than one direc-

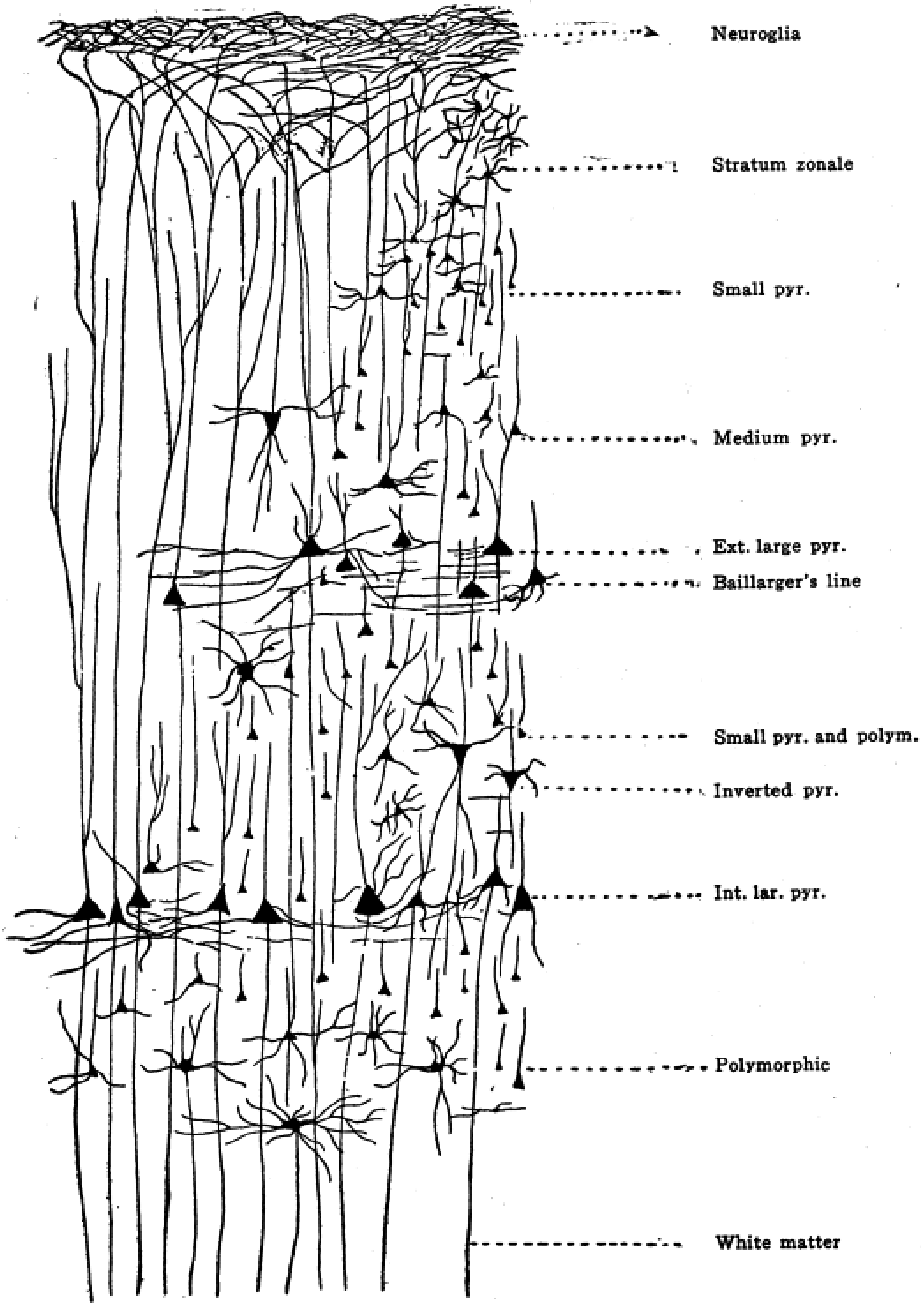

Fig. 5. Diagram of the layers of the typical cerebral cortex. The neuroglia appears at the external surface. The first layer of the cortex contains the spindle and polymorphic cells. (See Fig. 3.) . Among these cells the dendrites of other cells, and the axons and collaterals of the inverted pyramids of Martinotti branch freely. The layer of small pyramids lies next, The dendrites of these reach the first layer; the axons exhaust themselves branching among the deeper layers. The third layer is characterized by the medium pyramids. The relations of these are as the small pyramids. The fourth layer is characterized by the large pyramids. The axons of these may enter the white matter and pass to other parts of the nervous system. The fifth layer includes small pyramids and polymorphic cells. The sixth layer contains large pyramidal cells, and the axons of these may enter the white matter. The seventh layer contains spindle and polymorphic cells, whose axons also may reach the white matter and pass to other parts of the nervous system. Small pyramidal cells, multipolar cells, Golgi Type II cells, and inverted pyramids may be found through all except the first layer. The line of Baillarger coincides with the external layer of large pyramids.

tion. In the stratum zonale are found also Golgi Type II cells, whose axons branch very freely among the fiber elements of their immediate neighborhood. Amacrine cells are also described for the stratum zonale. These cells all unite in having as their function the coördination of the impulses reaching the cortex. By means of these complex relationships the impulses are subjected to various modifying influences, which have the effect of making the reaction following any given stimulation correspondingly efficient.

Second Layer

The second layer of the cortex, the layer of small pyramids, sends dendrites into the stratum zonale, and thus these cells are capable of being stimulated by the cells of that layer. The small pyramids of the second layer are rather short and broad, with basal dendrites which branch rather near their origin, and are not very long. The apical dendrites also are short, since they need no great length to reach the stratum zonale. The small pyramids send axons into the deeper layers, where they give off collaterals, which form synapses with the cells of the lower levels. The axons of these cells do not reach the underlying white matter. Among these cells also lie Golgi Type II cells, whose activity probably coördinates the activities of the small pyramids. Collaterals from the axons of the inverted pyramids also branch among the small pyramids.

Third Layer

The third cortical layer is composed of pyramids somewhat larger. It is called the layer of medium-sized pyramids. There are small pyramids and Golgi Type II cells found among the medium-sized pyramids also. The apical dendrites of this layer reach the stratum zonale and branch therein. The basal dendrites branch freely among the fiber elements of this layer, which includes the axons and collaterals from the small pyramids and the collaterals from the axons of the inverted pyramids. The axons of the medium-sized pyramids pass into the deeper layers, but do not seem to enter the white matter. They give off collaterals which branch among the basal dendrites of the deeper layers of pyramids, and which may also pass outward toward the stratum zonale. The medium-sized pyramids thus may receive impulses from the cells of the stratum zonale, from the small pyramids, from the inverted pyramids, and from the Golgi Type II cells. They send impulses to the deeper pyramids by their axons, to the Golgi Type II cells, and to the stratum zonale by the recurrent collaterals.

Fourth Layer

The fourth layer of the cortex is characterized by the large pyramids. This layer is coincident with the line of Bailarger in most cortical areas. The large pyramids send apical dendrites to the stratum zonale. Their basal dendrites are extremely long and branch very freely. The axons of these cells pass toward the deeper layers, and they enter the white matter. It has not yet been possible to separate them from the other descending fibers in studying the cortical relationships. In passing through the gray matter these axons give off collaterals which branch among the deeper layers. Some of these collaterals turn backward toward the cortex, and ultimately terminate in the stratum zonale. The external layer of large pyramids includes also some small pyramids, some medium pyramids, some Golgi Type II cells and the inverted pyramids of Martinotti.

The radiations of Meynert, including the axons of cells in the lower centers and in other parts of the cortex, branch freely among the large pyramids. The line of Bailarger is made up of these branching axons, the basal dendrites of the large pyramids, the collaterals and axons of the small and medium pyramids as they form synapses with the large pyramids, and other transverse fibers which have not yet been traced to their origin.

The external layer of large pyramids is thus capable of receiving impulses from the cells of the stratum zonale, from the small pyramids, from the medium pyramids, from the inverted pyramids, from the Golgi Type II cells, and from the incoming axons of the radiations. They send impulses by their axons to other parts of the nervous system by way of the centrum ovale and the fiber tracts, to the inverted pyramids, to the deeper layers of the cortex, and to the stratum zonale by their recurrent collaterals.

Fifth Layer

The fifth layer includes stellate and polymorphous cells. These have many dendrites which branch freely in a very irregular and eccentric manner in the same layer. This layer varies greatly in different parts of the cortex. The axons of these cells pass horizontally in the same layer, giving off collaterals which form synapses with other cells of the same layer, and which may turn toward the stratum zonale. The line of Bailarger includes these axons.

The cells of the polymorphic layer include Golgi Type II cells, pyramidal cells, and probably amacrine cells. They receive impulses from the small, medium and large pyramidal cells, from the incoming fibers of the radiations, and from the other cells of the same and adjacent layers. They send impulses by their axons to the deeper layers and to the more superficial layers.

Sixth Layer

The sixth layer includes the internal large pyramids. These are the largest cells of the typical cortex. In this layer are found, besides the typical large pyramids, polymorphic cells, small pyramids, medium pyramids, Golgi Type II cells and inverted pyramids.

The apical dendrites of these large pyramids pass to the stratum zonale, where they branch very freely among the cells of that layer. The basal dendrites branch freely and are very long. The axons of these pyramids pass into the white matter, giving off collaterals within the gray matter. These collaterals form synapses with the cells of the seventh layer, and some of them turn toward the external layers. They may reach the stratum zonale, and they give off branches in passing to the other layers.

The internal layer of large pyramids is capable of receiving impulses from the cells of the stratum zonale, from the small pyramids, the medium pyramids, the external large pyramids, the polymorphic cells of the fifth layer, the cells of the seventh layer, the Golgi Type II cells, and the incoming radiating fibers. They send impulses by their axons to other parts of the nervous system, and by the recurrent collaterals to other layers of the same cortical area.

Seventh Layer

The seventh layer of the cortex includes a very rich fiber plexus, which makes up part of the feltwork of Kaes. Within the external part of this feltwork lie the fusiform cells characteristic of this layer, together with polymorphic cells and inverted pyramids. The axons of the polymorphic cells and the fusiform cells may enter the white matter, but seem to be rather short. The axons of the inverted pyramids pass to the stratum zonale, giving off collaterals to the different layers in passing. The cells of this layer may receive impulses from the incoming radiating fibers, from the collaterals of the large pyramids of both layers, from the Golgi Type II cells, and from other cells of the layer. They send impulses to adjacent cortical areas and to the other layers of the same cortical layer. (Figs. 5, 6.)

In different areas of the cortex certain variations from the typical structure are found. These are mentioned in connection with the physiology of the special areas.

Fibrae Propriae

The different areas within the cortex are related to one another in function by means of fiber tracts. Adjacent gyri are connected by fibers which are short and are not to be classified as tracts, except in a general way. They are called fibræ propriæ. Rather longer bundles of these fibers are called fasciculi propriæ. Longer and better marked bundles make up the short association tracts, while still larger and longer masses of fibers are classed as long association tracts. It is not possible to draw any exact line between these various classes of association tracts. All are concerned in unifying the parts of the cortex, and it is by means of these tracts that related activity of the different neuron systems becomes possible. Because of the relative liminal values of the cortical areas so associated in functions, varying cortical activities are related in function in different individuals, and at different times in the same individual.

Short Association Tracts

The stratum calcarinum includes two groups of fibers, the longer of which lies rather more deeply placed than the shorter. The shorter fibers pass from the upper lip of the calcarine fissure to the lower lip. The longer fibers are immediately beneath these; they pass from the medial portion of the cuneus to the medial and inferior portion of the lingual gyrus.

The fasciculus occipitalis transversus cunei passes from

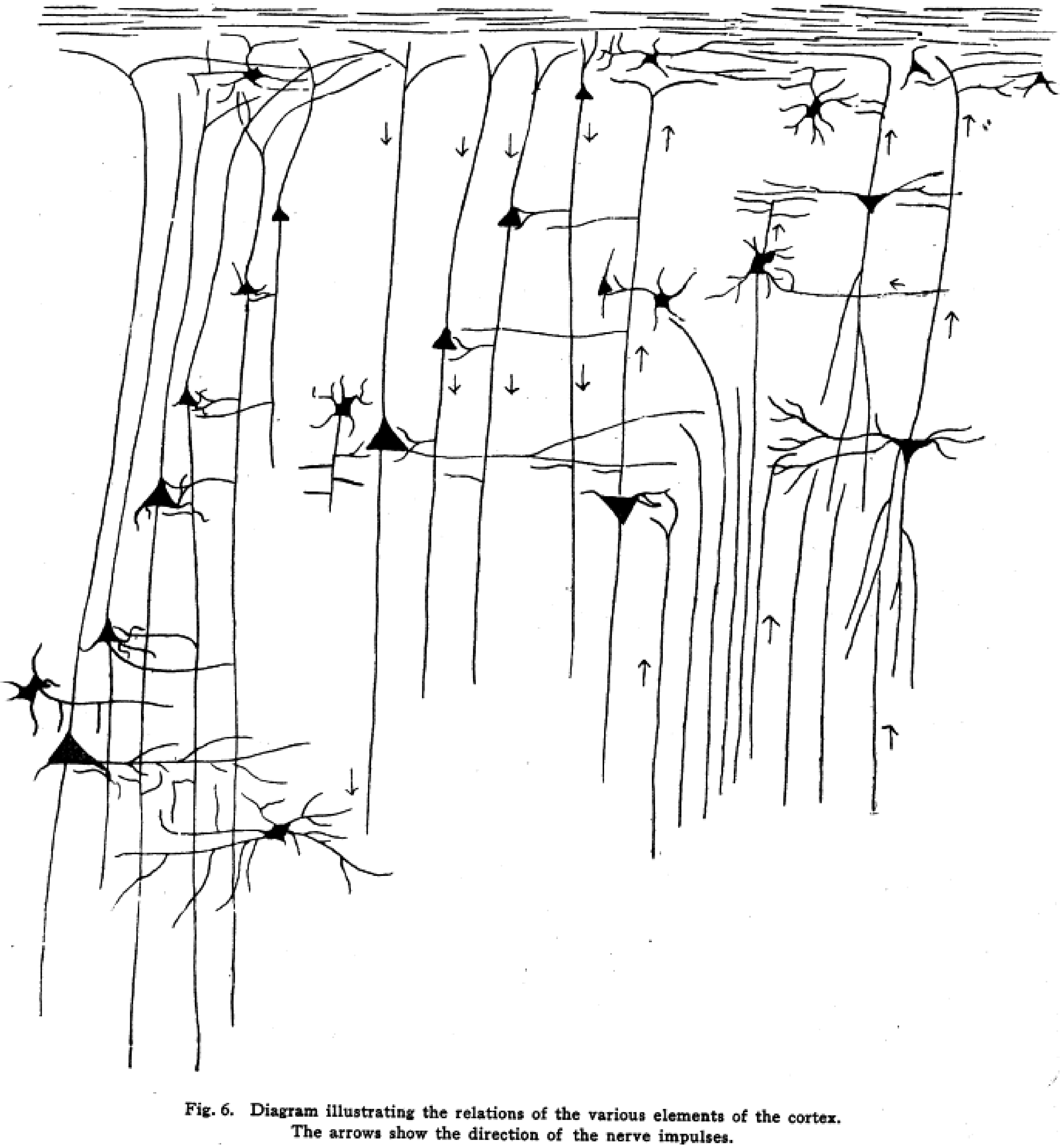

Fig. 6. Diagram illustrating the relations of the various elements of the cortex. The arrows show the direction of the nerve impulses.

the upper lip of the calcarine fissure first lateralward and then upward to enter the cortex of almost all parts of the occipital lobe.

The fasciculus occipitalis transversus gyri lingualis is similar to that just mentioned. It passes from the lower lip of the calcarine fissure to the occipital lobe through almost its entire extent.

The stratum proprium cunei passes from the upper lip of the calcarine fissure vertically upward, to be distributed to the cortex near the junction of the convex and the medial surfaces of the occipital cortex, and the adjoining area of the parietal lobe.

All of these shorter tracts are probably concerned in transmitting visual impulses from the primary visual area to the visual overflow, and from one part of the overflow to other regions, both of the visual overflow and of the intermediate areas.

Fasciculi propriæ are found in all of the intermediate areas. These tracts unite in function adjacent cortical areas. They vary in different brains, and are more pronounced in the brains of man than in animals, and in older people than in children. They receive their medullary sheaths later than the longer tracts or the projection fibers. They are thus probably concerned in the more complex coördinations.

Long Association Tracts

The long association tracts of the cortex include two groups, those which relate the hemispheres, and those which relate the different parts of the same hemisphere.

Corpus Callosum

This body is one of the most conspicuous factors in the human brain. It is less marked in the other mammals, is found only as a few fibers passing with the anterior commissure in monotremes, and is represented not at all in non-mammals. It is, in a way, a measure of cerebral development, but its exact place in the association of the nervous impulses is not known.

The fibers of the corpus callosum are the axons of almost or quite all of the cortical areas. These fibers are distributed to the contra-lateral hemispheres; to the corresponding area, and also to other areas of the cortex. It thus unites in function many parts of each hemisphere with many parts of the other hemispheres. It includes, besides the axons of the cells of association, collaterals from the descending tracts, notably the pyramidal tracts. By means of this relationship the two hemispheres act as a unit in function. Lesions of the corpus callosum are followed by symptoms which vary greatly, and are not to be explained at present.

Anterior Commissure

This tract is phylogenetically very old. It is composed of two parts, one of which transmits the olfactory fibers of each side to the limbic lobe and olfactory area of the other side; the other part transmits fibers from each temporal and occipital lobe to the contralateral temporal and occipital lobes. It is a part of the olfactory apparatus. Lesions of this tract are not to be localized ante mortem.

Hippocampal Commissure

This tract unites in function the hippocampus and adjacent areas of each side with corresponding areas of the opposite side. It also is concerned in the transmission of the impulses concerned in the reactions initiated by olfactory impulses. Injuries to this tract are not to be recognized ante mortem.

Homolateral Tracts

The cingulum, the fornix and the uncinate fasciculus are all concerned in the transmission of olfactory impulses, or of the impulses initiated by these. These tracts are probably not intimately related to consciousness, yet they are often concerned in modifying the reactions which occur, and thus indirectly they modify the conscious life of the individual.

Fasciculus Occipito-frontalis

This bundle arises from the cortex of the frontal lobe and passes to the occipital lobe, chiefly, and also to the temporal lobe at its posterior portion. The tract makes up the tapetum. No symptoms referable to its injury are described in the authorities consulted in the preparation of this volume, and the function of the tract is unknown.

Superior Longitudinal Fasciculus

This tract arises in the cortex of the occipital, temporal and posterior parietal lobes, and passes anteriorly to the frontal lobe. This tract transmits the impulses from the visual and auditory sensory speech centers to the motor speech center. The injury of this tract is followed by aphasia of the sensory type.

Inferior Longitudinal Fasciculus

This tract includes fibers passing from the temporal lobe to the occipital, and from the occipital lobe to the temporal. It seems to be especially concerned in the transmission of the impulses from the visual speech center to the auditory speech center, and contrariwise. It also transmits impulses concerned in the naming of things seen and in the memories of things named from the visual overflow to the auditory overflow.

Lesion of this tract is followed by the loss of the power of naming things seen, or reading aloud, or of remembering a thing named.

The Perpendicular Fasciculus (Wernicke)

This tract extends from the superior lobule of the occipital lobe to the inferior gyrus of the occipital lobe and the middle and inferior temporal lobes, and to the fusiform gyrus. It includes some fibers from the adjacent parietal lobe. Its function is unknown, except that it must be concerned in the transmission of associational impulses. This is included with the short tracts by some authors.

Motor Paths

After all the passing to and fro of the nerve impulses, there results ultimately a series of efferent impulses which relate the actions of the individual to his environment. In the broadest sense, nerve impulses which are totally unrelated to motor reactions are valueless, and they may be harmful. The physiological relations of the cortical activities are thus, in a sense, essentially pragmatic.

The ultimate end of all this tremendous structure of neuronic activity is the initiation of motor reactions. This is secured, finally, by means of the cortical efferent neurons. These pass to lower centers, which, by various coördinations and interrelations, affect the motor neurons of the first order, and the active structures of the body stimulated.

Direct Motor Paths

Two classes of efferent neuron systems carry the impulses concerned in the transmission of these motor impulses. Of these, the direct pathway represents the more highly developed relationship. The indirect pathway represents the older phylogenetic plan, and is built upon the centers which were active and fairly efficient long before the cortical centers had attained any degree of activity worth mentioning.

The direct pathway is composed, first, of the large pyramidal and probably the large polymorphic cells of the precentral gyrus. In this area the various muscle groups are represented within fairly well marked limits. The evidence in favor of this cortical representation of muscle groups is convincing.

Extirpation of the areas in animals is followed by the paralysis of the muscles stimulated by that area.

Stimulation of any given area is followed by the movements of the muscles represented by that area.

Cases of paralysis are found to depend upon lesion of the area in which the lost muscular activities are represented.

Experiments upon human beings whose brains are subject to surgical procedures verify the experimental stimulation of the animal brain.

In amyotrophic lateral sclerosis the giant pyramidal cells and large polymorphic cells of the motor area are found degenerated.

Pyramidal Tracts

The fibers, axons of the giant pyramidal cells and the large polymorphic cells, pass through the internal capsule and occupy the central three-fifths of the basis pedunculi. They pass through the anterior region of the pons and medulla into the spinal cord. In passing through the basal part of the brain, they give off certain collaterals, but very few of the fibers themselves are lost. Some few fibers enter the median nucleus of the thalamus, and perhaps a few enter the corpus striatum. Many collaterals enter the median nucleus of the thalamus, and a few perhaps enter the striatum. Quite large numbers of collaterals enter the red nucleus, substantia nigra, and the sub-thalamic region. These collaterals are finer than the axons from which they arise. They terminate within the centers named by forming synapses with the cells of those centers.

The fibers from the lower part of the precentral gyrus terminate in the nuclei of the cranial nerves of the opposite side from that of their origin. The fibers from the middle and upper part of the precentral gyrus pass onward into the spinal cord.

The fibers which arise from the upper part of the precentral gyrus, and from the neighboring region on the median aspect of the cortex, decussate in the lower anterior part of the medulla. The decussation of the pyramids is seen from the anterior external aspect of the medulla. These fibers carry the impulses concerned in the movements of the lower part of the body and the legs and feet.

The fibers from the middle part of the precentral gyrus remain upon the same side of the cord until they reach the segment of their termination. At that place the fibers decussate and enter the gray matter.

These fibers, the axons of the large pyramidal cells of the cortex of the precentral gyrus, are among the longest nerve fibers of the body. They form synapses with the cells of the central part of the gray crescent of the cord. The short axons of these cells enter into the formation of the pericellular baskets of the large multipolar cells of the anterior horns, and these, in turn, send their axons to the skeletal muscles.

The impulses sent by this direct pathway are concerned in the volitional control of the skeletal muscles. The cortical area is not so large nor so well developed in animals. It reaches its most complex and efficient development among those races who have made the most complex and most efficient reaction to the demands of life.

Indirect Motor Paths

The indirect pathways are much more complex, and the exact relationships have not been determined with any degree of accuracy. Almost all of the primary sensory areas of the cortex send descending fibers to the lower centers associated with the organs concerned in the specific energy of that area. The descending impulses from the visual area are carried to the anterior quadrigemina and the lateral geniculate body; the descending impulses from the auditory area are carried to the posterior quadrigeminates and the lower auditory centers; the olfactory tracts carry axons passing in both directions, etc. Now, it seems probable that these impulses are concerned in the maintenance of the nutritive relationships of the sensory structures, though they may be concerned to a certain extent in the motor phenomena of attention.

The intermediate and overflow areas send axons downward through the internal capsule, chiefly to the lower centers, and from the cells of these centers axons are carried to others, and so on through a number of interposed centers, until finally the muscles, both striated and non-striated, and the glands of the body may be affected. These are called the indirect pathways of efferent impulses.

The Fronto-pontal Tract

The fronto-pontal tract is that described in older books as the fronto-cerebellar tract. It arises in the cortex of the frontal lobes, anterior to the precentral sulcus — that is, anterior to the motor area. This part of the brain, in the left hemisphere, seems to be concerned with the coördination of those nerve impulses which relate the individual to his environment. The impulses arising in this region are carried to certain lower centers, and thus the bodily activities are governed in accordance with the results of the frontal coördinations. The fronto-pontal tract passes downward through the internal capsule, giving off fibers to the median nucleus of the optic thalamus and probably the globus pallidus, then it occupies the medial one-fifth of the basis pedunculi and passes onward to the nucleus pontis. It gives off either fibers or collaterals to the red nucleus and substantia nigra, and perhaps to the sub-thalamic nuclei. The tract terminates in the nucleus pontis. The basal ganglia mentioned, which are certainly of considerable importance in this connection, send fibers onward to still lower centers. The globus pallidus sends fibers by way of the olivary bundle to the inferior olivary body; from this body the olivo-spinal tract transmits the impulses to the spinal centers, and perhaps also to the cerebellum. The median nucleus of the thalamus sends fibers in the thalamo-spinal tract to the spinal centers and to the motor nuclei of the cranial nerves. The red nucleus and substantia nigra, and probably the sub-thalamic centers, send fibers to the motor nuclei of the cranial nerves and to the spinal centers by way of the rubro-spinal tract. Fibers from the red nucleus also may send fibers to the dentate nucleus of the cerebellum, though this relationship has been doubted. The thalamus and the corpus striatum of each side exchange fibers of association and send fibers to the contra-lateral bodies and to the other related centers.

From the nucleus pontis and the olivary body fibers pass to the contra-lateral cerebellar hemispheres. From the cortex of these hemispheres the axons of the Purkinje cells carry the nerve impulses, either directly downward to the cranial and spinal motor nuclei, or to the nucleus dentatus or the olivary body, and the axons of the cells in these centers carry the efferent impulses to the lower centers. Ultimately, the centers controlling both the somatic motor and the visceral motor structures are affected by the impulses from the frontal cortex and from the lower centers controlled by that part of the cortex.

The Temporo-pontal Tract

The temporo-pontal tract is that which has been described as the temporo-cerebellar tract. It arises in the cortex of the temporal lobe, probably in all three of its convolutions. The fibers, axons of the large pyramidal and polymorphic cells, pass by way of the internal capsule, the outer one-fifth of the basis pedunculi, to the nucleus pontis. It gives off fibers to the substantia nigra, and probably also to the thalamus, globus pallidus, red nucleus, and others of the centers around the base of the brain. The tract terminates in the nucleus pontis. The impulses carried by this tract are transmitted from the globus pallidus by way of the intermediate bundle to the substantia nigra, and probably neighboring centers, and to the inferior olive by way of the olivary bundle. The red nucleus, etc., send impulses partly by way of the rubro-spinal tract and partly by way of the brachium conjunctivum. the dentate nucleus and the cerebellar centers to the spinal and cranial centers. The nucleus pontis sends fibers to the contra-lateral cerebellar hemispheres, and these transmit the impulses to the cranial and spinal motor centers.

The nature of the impulses carried by the temporo-pontal tracts is very uncertain. It seems probable that a certain part of these impulses is concerned in relating the bodily activities to the sensory impulses from the auditory tracts. The stimulation of this cortex in the brain of the cat or the dog causes movements of the ears, and sometimes of the eyes; less often the head is moved.

Other Descending Fibers

Descending fibers, axons of the large pyramidal and stellate cells of the occipital lobes, are carried by way of the optic radiations to the lateral geniculate body, the anterior quadrigeminates and the pulvinar. The impulses carried by these fibers seem to be concerned in the control of the orbital tissues, and especially as these are concerned in vision.

From all areas of the cortex descending fibers seem to pass to the centers of the thalamus and the striatum. The cortical activities are thus very intimately associated with the activities of these lower centers. The structural basis for the relationship of the cortical centers concerned with the reactions called intellectual are thus able to control and to be modified by the basal centers, whose activities are concerned in the emotional and instinctive reactions.

CHAPTER IV

THE INHIBITIONS

To a very great extent the development of the human brain is a matter not of increased variety of possible reactions to given environmental changes, but to the increased development of inhibitory powers. The difference between man and the higher animals, then, is seen to be, not that he can do more different things than they can, but that he can refrain from doing more things than they can. And the difference between the higher and lower among human kind is, not that the higher are able to do more than the lower, though this is probably true, but the essential difference is, that the more highly civilized a nation is, in the best use of that term, the more able its citizens are to refrain from doing certain things.

Function of the Inhibitions

Inefficiency along certain lines of mentality is associated with a lessened number of possible associative reactions. But for the most part a loss of mentality, either as positive insanity or as the neurasthenic or psychasthenic states, is more characterized by a loss of the inhibitory powers than by a loss of the powers of active cerebration. Or, if the mental faculties do seem to be lessened, it is largely because of the lack of the inhibitory powers, thus permitting unwise and improper reactions to occur to the exclusion of those more carefully determined.

It is by means of the inhibitory activities that the adjustment of complex mechanisms becomes possible. With even the most complex possibilities of reaction, were every incoming impulse to be followed immediately by one of these, the powers of choice must be certainly limited. But with the action of the cells which inhibit activity, those nerve impulses derived from past experience, even though they be revived only through the activity of many cells, are enabled to affect the reaction, whether it affects consciousness or whether merely some lower center be affected.

Frontal Inhibitions

There is reason to believe that the frontal lobes of the brain are concerned with those associative processes which relate the personality of an individual with his environment. Other investigators see in the frontal lobes an immense center for inhibitory impulses. It is possible that both these views are correct. If the frontal lobes are chiefly concerned with the inhibition of the nerve impulses too hastily transformed into efferent impulses by the lower centers, then it is evident that this very function of retardation renders these lobes most efficient as controlling agents for the relating of the person to his environment. On the other hand, if the frontal lobes were, as their phylogenetic development and their structural relations seem to indicate, chiefly concerned with the determination of the individual's own place in the midst of things, then the increase of their inhibitory powers would follow speedily.

That the activity of the frontal lobes does exert an inhibitory power upon the activities of the lower centers is shown by the results of the injury of these lobes. Patients whose frontal lobes have been subjected to injury by trauma, pressure, or other pathological conditions show very great lack of the normal self-control. They yield unquestioned obedience to the dictates of anger, amusement, suspicion, or any other passion. The loss of this self-control is not seen in like degree in injuries of other parts of the brain, though it must not be forgotten that pressure abnormalities are transmitted by the almost fluid brain substance without interference.

The inhibitory action of the frontal lobes renders them of tremendous value in adding to the wisdom of all conscious reactions, and of many of those which are not present in consciousness.

Physiology of the Inhibitions

When the lower centers are stimulated by incoming impulses reaching them, the tendency is, of course, toward immediate discharge of the nerve impulses resulting from that stimulation as efferent or motor impulses; that is, if any center whose duty is the coördination of any certain action receives impulses increasing its activity from other parts of the nervous system, the effect of that stimulation is to cause immediate activity of that center, and thus an immediate reaction of a type depending upon the nature of the stimulation and the physiological condition of the center affected. This immediate reaction is exactly what occurs in the simpler reflexes and in the lower animals, for the most part. But just to the extent that the inhibitory powers of the higher centers, and especially the frontal lobes, are developed, just to that extent there is produced, not the prevention of the reaction, but its slight postponement. Thus, the center affected may receive impulses from other parts of the cerebral cortex, from the nerve cells in which are stored memories of previous related reactions and their results, from other nerve cells in which are stored memories of the nerve activity dependent upon the association of these experiences, from other cells in which are stored memories of the experiences of other people, of historical events, of various ethical or esthetical teachings. As a result of this inhibition, this temporary postponement of the reaction, the nature of the efferent impulses may be considerably modified. Perhaps it may be altogether prevented, perhaps much reinforced, perhaps modified in various manners. In any event the resultant reaction is the effect, not only of the certain immediate stimulation, but also of all the experiences of the past of the individual, and of the past histories of many other people. Thus the reaction is, or ought to be, much wiser than would be possible if sensory stimulation were followed by immediate motor activity.

It must not be forgotten that the physiological value of the inhibitions is to postpone temporarily the motor impulses and not to repress indefinitely any reactions. The temporary inhibition may be followed by indefinite postponement of the reaction, and the nature of the reaction may be greatly modified. If the algebraic sum of the impulses reaching the center whose activity has been postponed should equal zero, then probably no reaction would occur.

Inhibition of the Emotions

The centers most affected by this inhibition are those concerned in the emotional reactions. The physiology of these centers is discussed elsewhere. Inasmuch as these centers are those in which are coördinated the impulses concerned in securing the safety of the person and his race, and since in these centers the manner of the reaction is that dependent upon racial rather than upon individual history, we have these presenting, in their unmodified activities, the spectacles of the most destructive, the most suicidal, and the most dangerous of all reactions possible to animals or man. It is by the uncontrolled activity of the emotional centers that the most destructive actions are performed. By means of the inhibitory action of the higher centers these emotional reactions are subject to control, and thus serve as a source of much strength and pleasure in the performance of life's duties. It is, however, only when the relationship between the higher and inhibitory centers is normal and exact that these reactions give all of their proper force to life, and all of their normal enjoyment to those who live. With unimpeded expression, without guidance, these powers are frittered and lost, and in their expression destruction is certain. With the postponing effects of the inhibitions, the excessive and destructive action of the emotions is prevented, while under other circumstances the sane and chosen expression of the same emotions may be increased to a force beyond the unimpeded reactions, and the pleasure derived from that expression becomes increased to a degree unimagined by the person in whom the effects of inhibition are not manifest.

The activity of many of the reactions which are not ever or not usually a part of consciousness is postponed in the same manner. Even the action of the spinal centers is subject to the inhibition of higher centers. It thus occurs that under normal conditions there is probably never an immediate response to afferent impulses, nor an immediate reaction following even the most exactly coördinated series of complex associative impulses. In other words, there is present always, in the action of the very lowest as well as of the highest centers, some inhibitory, some postponing impulses, by means of which too hasty or too unguarded, or too unreserved reactions are prevented. Thus, there is afforded the time needful for each center to receive from other related centers those impulses which are concerned in the coördinate reactions of many centers; thus, too, the effects of the memory impulses, whether present in consciousness or not, are permitted to affect the ultimate reaction.

Because of this postponing condition the reaction of any center may be greatly increased. If the experience of the individual and of his race should be of a nature to show that the proposed reaction is for great good, for the prevention of great evil, then the effect of the postponement of the reaction increases its force and renders the action itself more permanent. On the other hand, if the experience of the individual and of the race is such as to indicate that the proposed reaction is better modified, then that modification must inevitably ensue. It is not probable that a complete prevention of any reaction often occurs. But the proposed reaction may be so modified as to become unrecognizable. For instance, the first effect of the presence of a burglar may be to kill him, but the second thought may lead to efforts toward his greater comfort and his reformation. So anger may be turned to pity, or pity to anger, under other circumstances.

Education of the Inhibitions

The inhibitory powers, like any others, are subject to educational influences. The child whose every impulse is afforded immediate and unimpeded expression becomes erratic, uncertain, easy to anger, and not in the least to be depended upon as a member of society. On the other hand, the child whose every expression is made the subject of discussion and reproof, who is permitted no speedy and unthoughted reaction, who stops to consider the effects of every action, such a one has excessively developed his inhibitory powers, and becomes inert, helpless, undecided. A rational development of the inhibitory powers is greatly to be desired. The ability to decide quickly and yet wisely, that is the desideratum. This is to be secured only by training the postponement and not the prevention of reactions. Let the child be taught to think about the effects of his performances, then let him be taught to decide quickly and finally the nature of his subsequent performances. The rational uses of the inhibitory powers, it must be recognized, are to postpone the reactions only just long enough to permit the receipt of other impulses from other centers, and not to prevent reactions. Thus, the nature of any reaction is subject to the effects of many experiences, but the fact that some reaction must occur as an expression of the recognition of certain environmental changes is probably inevitable. For example, if anything occurs which under ordinary circumstances would arouse the emotion of fear, there must, probably, be some reaction in answer to this environmental change. The inhibitions postpone immediate reaction. The effects of the impulses from other centers, from nerve cells concerned with the memories of the past experiences of the person himself and others with whom he has been associated and of whom he has heard or read, may cause his first impulse toward flight to be superseded by movements toward investigation, or the effect of his further consideration may cause him to run the faster. But it is very doubtful if ever the need for some answer to the original stimulation is neglected.

The Nature of the Inhibitions

The nature of the inhibitions has long been discussed. No satisfactory explanation has yet been offered for the phenomenon; the following is only tentative and is given with a full appreciation of the difficulties of explaining the matter in any feasible manner:

In the first place, it is known that the subminimal stimulation of a neuron may produce a latent period similar to that produced by efficient stimulation. This latent period may be increased by recurring slight stimuli, if these occur at intervals too great for the summation of stimuli to occur. It is known, also, that impulses which are ordinarily inhibitory are carried over the same nerves and tracts as those employed in transmitting impulses which increase the activity of the same structures. The descending impulses from the cortex to the spinal centers, for example, seem to be carried by the same tracts which carry the ordinary stimulating impulses. The effects of the removal or the disease of the cortical areas seem to show that the cell and fiber systems which transmit inhibitory impulses may also, under conditions leading to more powerful stimulation, carry impulses which are efficient in promoting neuron activity. Experimentally, it is shown that inefficient stimuli at longer intervals than those necessary for summation may prevent the stimulation of the neuron group for a considerable time, even in the presence of other sources of stimulation ordinarily effective.

The psychical side of the phenomenon is shown in a common experience; if inefficient reasons for the performance of any act are brought before any one for a number of times, and the act is not performed, even more powerful reasons — reasons which at first would have easily persuaded the individual to forceful reaction — are unable to arouse his activity. The indifference with which most persons view social and governmental conditions, which would be seen to be unendurable if they had been suddenly produced, is due to this physiological factor. "Too often seen, familiar with its face," is due, not to the frequent seeing, but to the fact that no efficient stimulus to opposition was produced by the sight of vice. To put inefficient reasons for performing any given act before an unthoughtful person is equivalent to increasing the difficulty of persuading him to that act at a later time. In teaching people, as well as children, or in persuading others to engage in any given line of effort, it is better to present no arguments at all until one has some hope of success in that persuasion. Also, when any given line of argument fails, it is better to cease referring to the matter again until other and more cogent arguments are at hand. This does not apply in those cases in which the repetition of certain teachings may lead to their acceptance. In this case there is no question of reasoning; there can be only the use of the demand or the statement in securing summation of stimuli in affecting the reactions of others. Arguments fail in producing the phenomena of summation probably because all reasoning is associated more or less vividly with coördinating impulses, both stimulatory and inhibitory. The appeal to the feelings and the repetition of facts may be summated, since the nerve reactions concerned in these conditions are not thoroughly coördinated, and the inhibitions are correspondingly less powerful.

Structural Basis

The structure of the cerebral cortex has been studied with much care, yet very little is known concerning the place of the neurons in affecting consciousness or in causing inhibition. The following schema has been built upon the facts of histology. It is offered with a vivid appreciation of its very slender foundation, yet it is perhaps as well verified as any such schema can be, with our present very limited knowledge and the handicaps under which investigations into the phenomena of consciousness and the inhibitions must be made.

The external layer of cells of the cortex, the layer of stellate and polymorphic cells, seems to be concerned in consciousness probably altogether. The primary sensory areas, except for smell, contain comparatively few of the cells of the external layer. The sensory overflows, the intermediate and motor areas, all are very well supplied with this layer. The cells are found best developed among the higher races of mankind, and are very feebly developed in the brains of animals. They are first affected by disease in certain degenerative processes associated with deficiencies of consciousness and of self-control. For all these reasons it is believed that these cells are the ones chiefly, if not altogether, concerned in producing the phenomenon called consciousness.

Inhibition seems to be a function of almost all nerve cells, under certain conditions. The inverted pyramids of Martinotti are especially adapted to the performance of this function. (Fig. 7.) These cells are sometimes found in

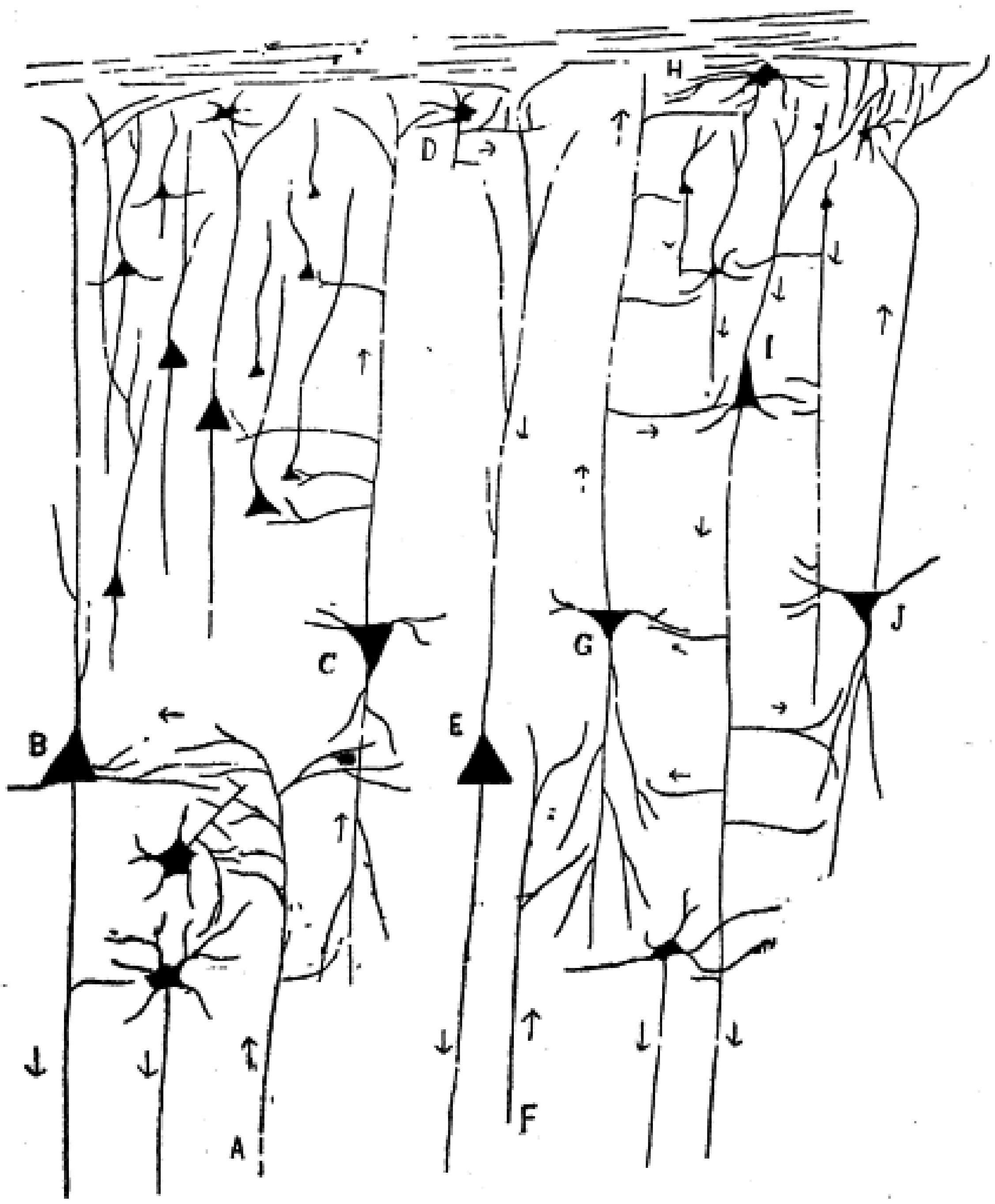

Fig. 7. Diagram of the elements of the cortex. The arrows show the direction of the nerve impulses. A, incoming axon from other parts of the nervous system; B, large pyramidal cell, which may receive the impulse directly from A, or indirectly by the interpolated neurons. The axon of B may transmit the impulse thus received to other parts of the nervous system, without affecting the neurons of the external layers of the cortex. It is probable that consciousness is not affected by these impulses.

A may transmit the impulses to C, an inverted pyramid of Martinotti, which carries the impulses over its axon to the cells of the stratum zonale, D. The dendrites of either the small, the medium, the large pyramidal cells, as E, may receive the impulses from D, and the large pyramidal cells, as E, may transmit the impulse thus received to other parts of the nervous system.

F, an axon from another part of the nervous system. The impulses carried by F may affect the inverted pyramid, G, which in turn may stimulate the cells of the more peripheral layers of the cortex, including H, a cell of the stratum zonale. The large, small and medium pyramids are affected by the action of H and of G, and these affect the cells of the lower layers again. The impulse descending from the stratum zonale may be transmitted to other inverted pyramids, as G and J, and the impulses thus again be carried to the cells of the stratum zonale. There is no way of determining the number of times this reaction may occur. It is probable that this series of impulses passing around this circular path is the physiological basis of inhibition, and thus of the mental process of "thinking things over." Ultimately the stimulation of I, a large pyramid, or of any of the cells of the seventh layer, may carry the impulses to other parts of the nervous system, and the final destination of these must be the motor neurons.

the brains of animals, but are much more frequently found in the human brain, and are then larger, with more complex structure. They are found most plentifully in the overflow and intermediate areas.

Physiology of the Inhibitory Neurons

The impulses concerned in the phenomena of consciousness and the cortical coördinations are probably as follows:

The sensory impulses from any environmental or physiological change are carried upward by the sensory tracts to the cortex, in which is located the primary area for the class of sensations under consideration. The fibers of the centrum ovale enter the gray matter, passing as far toward the external surface as the line of Bailarger. (In the auditory area the incoming fibers reach the external layer.) The impulses carried by these fibers then affect the cells, with which they form synapses. These cells include the pyramids, the Golgi Type II cells, and the polymorphic cells. The large pyramidal cells thus stimulated may initiate efferent impulses directly, without the intermediation of neurons of other layers. It is probable that when the incoming sensory impulse is of sufficient force, or if the large pyramidal cells have a low enough liminal value, the efferent impulse may be initiated immediately, and the arc thus concerned in the reaction need not include any effect in consciousness. In this way are produced those complex reactions, often the result of habit or of certain slightly abnormal conditions, in which activities which are usually considered necessarily conscious are thus effected without the intermediation of consciousness in any degree.

The impulses carried by the incoming fibers may affect the inverted pyramids of Martinotti. The axons of these cells pass to the outer layer of the cortex and there form synapses with the spindle-shaped cells and the Golgi Type II cells of that layer. These cells send impulses to the pyramidal cells, which all send dendrites into the stratum zonale. The impulses are carried downward by way of these dendrites to the deeper layers. The giant pyramids may be affected directly by this relationship, and the efferent impulses initiated by these may cause immediate reaction to the incoming stimulus. Or the impulses may be carried by way of the small pyramids; the axons of these send collaterals to the cells of the larger pyramids lying in the deeper layers; the axons of these, in turn, may send impulses to others, until a large number of neurons have been subjected to the stimulation. The efferent impulses are thus very notably increased over those which have resulted if the first incoming stimulus should affect the large pyramids directly. At the same time and in the same manner the impulses carried from cell to cell in the cortex affect those cells, the giant pyramids and the polymorphic cells of the seventh layer, and the axons of these carry the stimulation to the overflow of that sensory area. In the overflow areas the cells are adapted to the retention of the effects of previous stimulations; that is, these cells, probably of the stratum zonale, are capable of being so changed by repeated stimulation that their liminal value is lowered more or less permanently. When the liminal value thus is lowered constantly, less amounts of stimulation are needful for the initiation of nerve impulses by these cells. They send efferent impulses, as all nerve cells do when stimulated, and these impulses are carried to other parts of the cortex. Again, the cells in the stratum zonale are affected, and these bring about the phenomenon of consciousness again. When this occurs, the individual is said to "remember" the circumstances whose occurrence originally stimulated the neuron systems concerned.

It may happen that the immediate discharge of the efferent impulses does not occur. This postponement of reaction is called inhibition. The impulses sent, either to the primary sense areas or to the overflow areas or to the intermediate areas of the cortex, may be carried to the external layer, as already described, and the descending impulses may be carried to the small pyramids, then by the axons of these to the inverted pyramids of Martinotti. These send axons toward the cortex, the cells of the stratum zonale are again stimulated, and the impulses may be again transmitted by the same pathway of small pyramids, inverted pyramids, and again to the cortex. The efferent impulses may thus be postponed. Each time the stimulation is carried over any given pathway the neuron systems of that pathway have lower liminal value than before, and the tendency is for the succeeding streams of impulses to follow that pathway. So, if any given reaction is once prevented, it becomes easier to prevent it again.

The reactions just described are probably never so simple as has been given. It seems probable that even the simplest reactions of which we are conscious require the associated activity of many parts of the cortex. But the series of occurrences is probably as described, except that many areas are active at the same time, and consciousness at any given time is the sum of the effects of the cortical activities.

If the reaction occurs as described for inhibition, the effect produced in consciousness by the series of impulses passing through cells of differing degrees of liminal value, causing repeated stimulations due to the effects of past reactions, is that of "thinking the matter over." The feeling in consciousness is that of deliberately withholding reaction, whereas really it is the condition of the cortical neurons which prevents the reaction, and the conscious phenomena are merely the effects of this withholding.

This inhibition permits the impulses sent to other parts of the cortex to affect the cells there, and the impulses initiated by the activities of these cells, affected as they are by the sum of all past activities, result in sending increased stimuli to the overflow area, or the intermediate area, whose cells are concerned in the reaction. These impulses may reinforce the effect of the original stimulation, or they may stimulate more forcibly the inverted pyramids, and thus perpetuate the inhibition. Or the impulses from the area finally affected may initiate the stimulation of other cell groups, and some very different reaction, only distantly related to the original stimulus, may occur. This reaction may be directly opposite to that which would have been expected to follow the original stimulus, if no complicating factors had arisen.

Any given impulses or series of impulses, or the whole complex of groups of impulses arising from any circumstances, may be held within one of the circular phases of neuron action for some time. It is a matter of common experience that certain reactions may be a part of consciousness for a long time, and that the reaction may be subjected to very much consideration before a judgment is finally decided upon. Now, the physiological action is that of a series of very complex neuron actions. The impulses passing through the circle of neurons, the cells of the stratum zonale, the pyramidal and Golgi Type II and other cells of associational function, reach the inverted pyramids, by means of which the impulses are again carried to the cortex, and so on. At the same time impulses are being carried to other parts of the cortex by these same associational cells; these are in turn stimulated, and the impulses thus initiated add to the delicacy and propriety of the final reaction.

It may occur that the balance between the liminal value of neuron groups and the effects of the activities of the association areas is so exact that no reaction at all is permitted. Under such circumstances a sort of fatigue results. The neuron groups being subjected to the constant stream of impulses, which are not varied nor permitted to cease, become affected, as the neurons are under similar conditions throughout the nervous system. First, the liminal value is lowered, so that amounts of stimulation originally inefficient may initiate excessive reactions. Under such conditions, whatever environmental changes occur in the life of the individual are apt to affect the cells associated with the active circle. This condition has its place in consciousness as the feeling people have when they are intently pondering some problem; if anything else is perceived at all, it is apt to be perceived as being in some way related to the matter in hand at the time. This is especially true of all matters associated with emotional states, or with feelings of an intensely personal character.

The tendency seems to be for arcs of nervous pathways to become smaller. This is due to the fact that in complex pathways those cell groups whose liminal value is lowest are most efficiently stimulated. Now, when these circular streams of impulses are produced, the cells most liable to stimulation from other parts of the nervous system react to those impulses, are less irritable to the circular streams, and are finally left out of the circle. The path of the impulses is more easily understood by reference to the diagrams. The series of neuron activities thus produced is the condition known as "split-off" complexes, etc., by various authors.

There may be harm in these circular reactions if the nervous system is slightly abnormal. It is extremely improbable that a normal person should suffer from such conditions unless the original stimulation had been of a very intense and injurious nature.

THE INHIBITIONS

If the circular stream of impulses should be permitted to continue indefinitely, it is probable that the neuron groups would be fatigued to the point of inactivity. The further history of the neurons would depend upon their nutritive conditions, the amount and nature of the stimulation reaching them later, and the integrity of the associational structures.

CHAPTER V

THE NATURE OF CONSCIOUSNESS

It is very evident that it is impossible to define consciousness in any exact sense. It is just as evident that it is impossible to define any primitive conception. Such terms as energy, matter, life, and all other terms applied to simple ideas, are, by that fact, impossible of definition, just as the axiom in mathematics is impossible of proof. Consciousness is one of these ideas.

Yet, while the exact definition of the term is impossible, it is, like other primitive ideas, capable of a certain amount of elucidation. In order to use the term at all with profit, it is necessary to agree upon the application of the term. This must be done, as in the case of other primitive ideas, by the statement of certain relationships between consciousness and other ideas with which we are more or less familiar. It must be recognized that in our inability to exactly define consciousness we are placed in exactly the same position as we are in our inability to define matter or energy or any other primitive idea. We may only explain the use of the word matter, energy, etc., by the statement of the relationship between matter and movement, for example, or between energy, heat and light, and by otherwise expressing relationship. In the same way it becomes possible to understand something, not of the real nature of consciousness, but of its relationship to other phenomena of nature, and especially to other phenomena of physiology and biology.

THE NATURE OF CONSCIOUSNESS

Definition

Consciousness is a phenomenon associated with the activity of the cells of the cerebral cortex, probably of the external layer. It is associated with the activities of all parts of the cortex, and it is vivid or dim according to the metabolism of these neurons. Consciousness is dim when the metabolism of the cortical neurons is less energetic, and is vivid when the metabolism of the neurons is most energetic. Of the entire extent of the cortex, those areas in which metabolism is most energetic represent their specific energies most vividly in consciousness. Increased activity of the sense areas gives rise to increased vividness in consciousness; increased activity of the motor areas gives rise to an increased sense of power and volition in consciousness. There are infinite gradations in the vividness of consciousness, according to the infinite gradations of neuronic activity. There are infinite variations in the characteristics of consciousness, according to the infinite variations in the relative activity of different neuron groups at different times.

Grades of Consciousness

All grades of consciousness exist in the factors present at any one time. No consciousness is probably associated with the meager activities of undeveloped neurons, as, for example, the neurons of the visual area of the cortex of the person born blind, while the most vivid consciousness is associated with the activity of neurons often stimulated by incoming sensory and associational impulses. Between these extremes are found almost an infinite variety of grades of consciousnss. It is no more possible to establish limits and grades of consciousness, levels of minds above minds, than it is to classify the tints of yesterday's sunset, or to establish the gradations of twilight during a winter's evening.

Consciousness and Neurons

Every factor in consciousness is capable of being expressed in terms of neuronic activity. Every habit of thought and feeling is capable of being expressed in terms of neuronic physiology or morphology. The characteristics of personality are probably due to the relative structural relationships between neuron groups and the physiological activities of the neurons so related. If our knowledge of the physiological processes of the cortical neurons were complete, it should be easy to anticipate not only the manner in which any person would act under certain circumstances, but also how he would feel in so acting. It is not necessary to say that we have as yet no such exact information concerning physiological processes. It is also true that the difficulties in the way of research into the physiology of the cortical neurons are so great that it now seems impossible that the problems associated with the physiology of the cortical neurons should ever be answered.

Stream of Consciousness

The term "stream of consciousness" is used. This depends for its forcefulness upon the fact that there is a constantly changing relationship between the relative energies of the different neuron groups. Not only are the different primary sense areas subject to constantly varying stimuli, but the overflow areas are constantly being stimulated by these sensory impulses, and the intermediate areas are, in turn, being stimulated by these and by one another, and so there must at all times be a succession of states of consciousness compelled by the constantly varying conditions and relations of neuronic activity.

Consciousness is not to be regarded as a force, in any sense of the word. Consciousness is no more a force than the sweetness of sugar, or the pinkness of a rose, or the brightness of the stars, or the beauty of the sunset sky. Indeed, it is not so much a force as sound, since sound waves are really a form of energy; nor as light, since this also is a form of energy. Consciousness is merely a function of the cortical neurons, so far as physiological knowledge is concerned. It is absolutely valueless as a stimulant of physiological activity. But the conditions of the cortical neurons which may affect physiological reactions may, and often do, affect consciousness, and this is the reason why so many people think the mind is the efficient factor in producing the physiological effect. It is the activity of the cortical neurons which produces both the physiological changes and the variations in consciousness.

The Body-mind Controversy

The idea of the great importance of the control of the mind over the body arose from a misunderstanding of the physiology of the cortical neurons. Much of what is ponderously explained by the effect of the mind over the body is made simple and easily understood when it is recognized that it is not mind, but the cerebral neurons which affect bodily activities. Strength comes, not because of the consciousness of strength, but the consciousness of strength comes because the cortical neurons are stimulated in a certain manner. It is true that such information is not always exact. Often the consciousness of strength may be associated with even a dying condition. This is true of all our sensations; not one of them is to be depended upon absolutely. But so far as we are conscious of anything at all, we are conscious through the activities of the cortical neurons. And while this activity may not give exactly correct information, it is the best we have at present.

Physiological Aspect

The study of the physiology of consciousness, then, is a study of the physiology of the cortical neurons. Such a study inquires into the effects produced in consciousness by neuronic activity, and also into the relationships between the centers of the nervous system in their effects upon consciousness, either directly or indirectly. The effects of somatic conditions upon the activities of the cortical neurons, the effects of the environmental conditions upon the body itself and thus upon cortical activity, the effects of cortical activity upon the lower nerve centers and thus upon the body itself, and the manner in which relations are formed between the cortical neurons and the external world, all are problems which are associated with the physiology of consciousness.

The facts and conclusions of this study should be of value to educators, and especially to those who deal with abnormal persons. In this connection the original meaning of the word "doctor" as "teacher" must be suggested.

In this study it is needful to limit the factors under consideration to the physiological aspects of the problems under consideration. Many very interesting, and perhaps, under other circumstances, very helpful, factors must be eliminated from this frankly physiological study of consciousness. The elimination of these other considerations from this discussion does not imply any denial of their existence. In the study of astronomy no mention is usually made of the "soul of the universe," or of the marvelous beauties of the nightly sky, or of the ultimate destiny of the stellar system. So, in studying the physiology of consciousness, the philosophical, and esthetic, and idealistic view may be eliminated in the same way as these same views are eliminated in the study of the physics or the chemistry of the physiology of digestion or circulation.

Function of Consciousness

It seems probable that consciousness is developed pari passu with cephalization — that is, with increasing complexity of reaction to environmental variations, with increasing complexity of neuronic relationships, and with increasing complexity of the environmental factors as affecting the sensorium. Consciousness is of value only as it increases the efficiency of the reactions.

If the environment of an individual be made larger, as it is by the increased efficiency of the sensory neurons and the neuron groups associated with these, the reactions of the individual must be made more efficient. If intermediate and overflow areas add to the complexity of the reactions possible to any given stimulation, and consciousness is associated with this increasing complexity, only the added efficiency is able to approve the increased metabolic expenses.

Only as the phenomenon of consciousness adds to the vigor, and force, and efficiency of the race is its existence proved to be worth its price.

Extra-neuronic Consciousness

This rather materialistic view of consciousness arouses many questions. Are there no other forms of consciousness than those associated with the activity of the cortical neurons? This question is not to be answered from the physiological standpoint. It is not ever safe to hazard negative statements in the absence of absolute proof, and absolute proof is a thing which it is impossible, at present, to secure. If it were possible to catch ideas without any connection with physiological processes, the matter would be solved for ever. Or if it were possible for elements of consciousness never before experienced to become present to any individual, then would the matter be settled, in a certain sense. But neither of these things seems to be possible. The only attempt which is being made along such lines was begun by the Psychical Research Society. The "ghost stories" accumulated by this organization are alike in failing to eliminate the possibility of physiological explanations of the marvelous occurrences. In order to secure evidence of value, the conditions experienced by certain chosen individuals should be related in order; then the number of those experiences which seem to be associated with the occurrence of circumstances outside the realm of the experiences of these persons should be noted. Elements whose association might have led to the conclusions which have part in the so-called psychical information should be eliminated from the final summing up of results and the probabilities of error estimated, together with the chances for coincidence. Such experiments, including many factors, and being performed upon normal persons as well as upon those blind and deaf from birth, should give exact information as to whether (1) consciousness is possible in the absence of physiological activities, and (2) whether ideas are capable of being transmitted without the intermediation of sensory impulses. There is, at present, no evidence that either such condition is present.

Nature of Volition

The world-old question of the "freedom of the will" arises in connection with the physiological interpretation of consciousness. In physiological terms, volition is the consciousness of the activity of the cortical neurons concerned in producing motor activities, either in the primary motor area, in which the reaction occurs immediately, or in the motor overflow area, in which the memories and probably also certain decisions are stored.

As to "freedom of choice," what is it that is meant to be free? The expression of personality is that which is usually understood by freedom of will. If personality means anything in the physiological sense, it means the sum of characteristics, mental and physical; or in other words, individuality is the sum of certain inherited characteristics, plus the variations produced, as these have been subjected to the action of a certain series of environmental variations. From the so-called mental aspect, individuality depends upon the structural relations of the neurons plus the physiological conditions of the neuron systems as they are modified by use and by environmental factors. The only "freedom" desirable, then, is that there shall be no abnormal condition interfering with the passage of nerve impulses from any cortical area to other related cortical centers, and that no impediment shall exist to the activities resulting from the coördination of the nerve impulses through and by the various cortical centers. For certainly no greater efficiency is to be desired than that resulting from the normal activity of normal neurons, acting in accordance with the present sensory stimulation, modified by racial and individual memories and associations. All the freedom needed is found in the activities of normal neurons, in normal bodies, placed in the midst of a normal environment.

Hesitancy

Hesitancy is the consciousness of inhibitory process in the cortical neurons, with simultaneous activity of the neurons of the intermediate areas. Choice is the consciousness of the increased activity of certain neuron groups, often, but not always, motor. Reason is the effect produced in consciousness by the passing of impulses to and from the different intermediate and overflow areas. Judgment is the consciousness of the activity of motor areas, following the process of reasoning, and usually associated with activity of the language centers. Memory is the effect in consciousness of the repeated activity of neuron groups, as these are stimulated from cortical centers.

Attention

Attention is the effect in consciousness of excessive activity of any given cortical area. Marked activity of any cortical area is usually associated with efferent impulses from that center.

Attention which is called active or volitional is the effect produced in consciousness by the increased metabolism of the cortical neurons of an area subjected to stimulation by the impulses from the intermediate or overflow areas. The sense of volition in attention depends upon the existence of the activity of the cells of the motor areas. The attention called passive is the effect in consciousness of the increased activity of the cells of some primary sense area, resulting from increased stimulation.

In terms of psychology, the active volition is that which the person himself chooses, as in applying himself to some line of study, though it may be neither interesting nor pleasant. Passive attention is produced by external stimulation of a marked type, as a blow, a loud sound, a bright light, etc.

Consciousness of Personality

The consciousness of personality depends upon the normal relationship between a series of neuronic events. The activities of the neurons of the anterior intermediate areas are concerned in the coördination of the impulses which relate the individual to his environment, and it is the consciousness aroused by these activities which we call self-consciousness, or the consciousness of one's own proper place in the midst of things — of his relations to his environment and to his fellow man. With the loss of the functions of these areas the person is not properly oriented to his circumstances. The condition is most conspicuously displayed in senility and in paresis. In both of these conditions, as well as in certain other diseases, the pathological process may affect first the frontal lobes. There is a slow degeneration of the neurons of the cortex, first those more superficial, then the deeper neurons. At first there is not produced any paralysis, nor any pressure symptoms. It often occurs under such conditions that very exact pictures of the effects of loss of function of the anterior association areas are shown. The person so affected loses his sense of relationship with his fellows; he becomes careless of the opinions of other people, is inordinately vain, or considers himself a person of tremendous importance, or of fabulous wealth, or in other ways shows a lack of appreciation of his own proper place. At the same time, he may show as great intelligence in regard to things not personally related to him as ever. In such cases, if death occurs early in the disease, it is usually found that the left frontal cortex is chiefly or alone affected. If death occurs later, it is usually found that these areas show the oldest lesions.

Since these areas receive the impulses arising from visceral changes, and since the longer tracts carry impulses from almost every other part of the cortex to the frontal lobes, it is evident that this consciousness of personal relation to the environment is capable of being affected by many conditions.

Probably the impulses from the body itself, including the viscera, are of importance in modifying the consciousness of personality, though this matter is not easily subject to any tests. Under abnormal conditions of visceral disorder the ideas of personality often become changed. A sleep occurring after long or wearying or sleepless days is often followed by a recognizable space of time during which one is unable to orient himself to his surroundings. The same condition is sometimes found after anesthesia or after great pain. In one case there was a period of great pain, followed by unconsciousness, probably associated with a cardiac disturbance. The process of recovery to consciousness was associated with a total loss of personality. The patient described a universe of pain, without personality, simply a whirling of objectless and subjectless pain, which lasted, as she expressed it, for several eternities. Consciousness of herself as suffering pain followed, then came a peculiar sensation as of a body without parts, then consciousness of arms followed a reflex movement, then at once consciousness of the entire body followed. Similar conditions may be associated with nightmare, delirium, and under various abnormal conditions of the cerebral cortex.

Dissociation of Personality

As a result of certain not very well studied pathological conditions of the cortical neurons a condition called dissociated personality may be produced. This condition has its physiological analogue in the condition of the normal person who is just awaking from a sound sleep. He may be unable to "place" himself for a part of a minute, or even longer.

The physiological basis for the condition lies, probably, in the interruption of the effect in consciousness normally produced by the constant cortical activity; that is, after unusually sound sleep, such as follows unusual fatigue, but not otherwise abnormal, the cortical neurons probably either fail in assuming their functions with their accustomed facility, or during such sleep their activity is rendered slightly abnormal. The lack of any exact knowledge concerning the metabolism of the cortical neurons during sleep renders it impossible at present to decide which, or whether either, of these possibilities is the true solution of the problem. At any rate, the slightly abnormal failure of the consciousness of personality under such conditions brings the phenomena of dissociated personality into line with the conditions associated with practically normal life and mentality.

In the presence of shock, or long-continued neurasthenic or hysterical conditions, the activities of the cortical neurons become unbalanced. Certain neuron groups, being acted upon by paralyzing poisons, display great eccentricities of conduct. Certain entire areas of the cortex may become non-functional, so far as the production of consciousness is concerned, yet memories may be stored during this stage of non-function of the neurons concerned in consciousness; that is, the hysterical person may be unable to see certain colors or objects placed slightly on one side of the field of vision. Yet after recovery the patient may describe the very object and colors to which he had been blind. This peculiar condition has been so often described that the fact is probably indisputable.

The structural basis for such conditions probably lies in the peculiarities of the cell structure of the cortex. There is reason to believe that consciousness is affected by the activity of the cells of the stratum zonale. If these cells fail in their physiological requirements, if they are starved, or subjected to great pressure, or poisoned, consciousness is variously affected.

Functional Variations

The possibility of being so affected by stimulation as to reply to subsequent stimuli with greater ease seems to be a function of all living cells in different degrees, and this seems to be peculiarly a function of nerve cells, of all nerve cells, probably. When cortical neurons are subjected to a series of stimulations, their metabolism becomes variously modified, so that they reply with greater ease to subsequent stimuli of the same nature. When the cells are thus stimulated by subsequent stimuli, they may cause the stimulation of the cells of the stratum zonale, and the effect in consciousness is that of a memory.

Stimuli may, under abnormal cortical conditions, affect the cells of the deeper layers of the cortex without stimulating the cells of the stratum zonale. The person under such circumstances would not be conscious of the sensory impulses reaching the primary sense area, because of the temporary paralysis or disuse of the stratum zonale cells. But these impulses might affect the metabolism of the deeper cell layers of the cortex, and these cells, being subjected to appropriate stimulation, might bring about the stimulation of the stratum zonale cells of the overflow area, and the consciousness of memory would result.

Insular Consciousness

When this abnormal cortical activity occurs, there may be produced a peculiar insular or lacunar form of consciousness, in which alternating areas of the cortex are subjected to this loss of function in such a way as to cause alternating personalities. Any temporary paralysis of the neuron systems by which the anterior association areas are related to other parts of the cortex would result in losing to the individual all sense of personality for a time. The activities of other cortical areas are usually partially retained, so that persons thus affected do not lose the power of speech, of using good language, of counting money, and of buying and selling with a certain ability. They retain most of their habits and faculties, though these may be subject to great variation in the different personalities. The instinctive and emotional states usually are greatly varied because of the variations in the liminal value of the different neuron systems which carry inhibitory impulses.

Multiple Personalities

The number of personalities in which any person may dwell at different times is not known to be limited by anything except the length of the patient's life and the time which is employed in the different states as they follow one another. Many physicians suppose that exact information concerning the occurrences of these alternating lives may be secured by hypnotism. But the extreme irritability of certain neuron groups, together with the comparative inefficiency of the inhibitions in hysterical persons, lessens the value of this method of securing information concerning such people. Statements made under hypnosis should be very carefully verified before any conclusions concerning the matter should be accepted.

Multiple personality may be defined as the abnormal consciousness associated with the activity of the anterior association areas following some disturbance of the functions of the neuron systems relating this area to other parts of the cortex.

Recognition of Truths

It has been noticed that of all things recognized as true, there are some things which seem to have a greater truth, or a higher truth, or a finer truth, as it is variously termed. The facts of the newer scientific attainments do not impress us as being quite so beautifully true as do the facts of older truths. No description of a colony of bacteria could now inspire a poem, though that culture might be the result of greater real bravery than any heroism of ancient times. For example, in the study of yellow fever, lives were risked and lives were lost in order that facts might be determined concerning the deadly scourge. Facts were determined, and for every life lost thousands have already been saved, while the future is full of life which would have been sacrificed to the fever under ignorance. In all history is found no braver deed than this, yet where is the poet who sings of such courage? It is said that "time makes ancient good uncouth," but it is time that makes ancient good a thing of poetry and beauty. New facts are not in themselves inspiring; new attainments need mellowing until they are sweet with many days of sunshine.

Consciousness of Beauty

Cortical association processes which follow a series of neuron groups whose liminal value has been lowered during racial development are those processes which are concerned in the consciousness of the recognition of truths. A certain pleasure is associated with the recurrence of activity of cortical neurons, and this sense of pleasure gives the sensation of the beauty of the older truths, the poetry of deeds long since performed bravely, and the consciousness of being uplifted, and inspired, and encouraged, which results from the appreciation of the truths long known, and thus called "everlasting."

Truths newly discovered, which are not related to the so-called "higher" truths, do not arouse such feelings. This is partly due to the lack of the associations which are brought into play with the recurrence in consciousness of ideas before experienced, but it is also due in part to the fact that the newer facts have not any series of neuron groups ready for their reception. The science of to-day begins the preparation for the "higher" truths of to-morrow. The foundation for all grandeur and nobility of thought must be laid in the solid and undecorated facts; but when the facts have been subjected to the association processes, when complex relationships are established between the neurons in which are laid down the memories of the facts, the appreciation of their significance, and the coördination of the motor reactions which give efficient reply to the environmental variations upon which all this nervous activity is based, then comes the time when the seeds of truth in the mere facts blossom into the beauty of feeling and expression; the fruit that they bear is achievement and progress.

CHAPTER VI

THE GANGLIONAR CENTERS OF THE CEREBRUM

Those centers of earliest phylogenetic development lying around the base of the hemispheres are concerned in the reactions which answer most speedily and forcibly the environmental changes to which the race has been accustomed. While the cerebral hemispheres were developed to a certain extent among animals lower than mammals, and while they are a conspicuous factor of mammalian brains, yet their functional development seems to be a matter of comparatively recent times. Even among mammals of considerable development the cerebral cortex seems to be largely non-functional. The centers around the base of the hemispheres, the nuclei of the thalamus and corpus striatum, the other interbrain centers and the midbrain centers, seem to perform the functions of properly relating the reactions to the variations of the surrounding conditions. Even among man these centers appear to control those reactions of immediate reply to certain environmental conditions.

Phylogeny

During the phylogenetic development of these centers they became functional in giving reply to many and varied changes, and these duties they still perform, in man, without the intermediation of consciousness. Through the activity of these centers reactions are controlled which have every appearance of purposeful foresight, and which yet are not associated with consciousness in any degree. This function of the lower centers is of great biological significance, since the activities of these centers secure for the cortical neurons the time and energy needful for the performance of those duties concerned in the conscious phenomena. The lower centers control those reactions called instinctive, or emotional, or affectional, which depend upon racial history for the effectiveness of the answer which they make to environmental changes.

Structure

The structural relationships of these ganglionic centers may be given in brief. The corpus striatum, the optic thalamus, the hypothalamic nucleus, the red nucleus and substantia nigra are those most easily recognized. Probably the claustrum should be included. The interpeduncular ganglion, the central gray matter around the aqueduct of the cerebrum (Sylvius), the nucleus pontis, and perhaps others of the groups of cells in the interbrain, midbrain, pons and medulla may be concerned in modifying the nature of the instinctive and emotional reactions. The cerebellar cortex and ganglia seem to be concerned in coördinating the descending impulses, but not in determining the nature of the reactions.

The Corpus Striatum

The corpus striatum is a part of the cerebral hemisphere. It is developed from the floor of the cerebral vesicle partly by a thickening of this floor with an associated specialization of neuron groups, and partly by the ingrowing of certain fiber groups from its own centers and from other parts of the nervous system. Phylogenetically, it is of great age. Its first relationships were with the olfactory impulses, as is the case also of the cortex itself.

The corpus striatum is of rather complex structure. It includes centers which are probably of different functions, as they certainly are of different relationships. The body is divided into two parts by the internal capsule; the inner of these is called the caudate nucleus, the outer is called the lenticular nucleus. The lenticular nucleus is divided by bands of fibers into three parts, at least. The outer of these is the putamen; the inner masses are grouped as the globus pallidus.

The Putamen

The putamen is the outer zone of the lenticular nucleus. It is separated from the claustrum by the thin external capsule. The insula occupies a position just external to the claustrum, and is of about the same extent as the putamen. The putamen is pigmented, and is rather freely supplied with blood. This gives it a reddish color, quite different from the color of the underlying globus pallidus. The putamen sends a large bundle of fibers to the thalamus, probably chiefly to the median nucleus. The putamen exchanges fibers with the caudate nucleus, the globus pallidus and the cortex, chiefly of the insula and the fronto-parietal region. The relations of the putamen to the claustrum are not well studied.

The Globus Pallidus

The globus pallidus is light in color, partly because its cells contain no pigment and partly because its blood supply is rather scanty. Like the putamen, it exchanges fibers with the caudate nucleus, the thalamic centers, probably the median nucleus chiefly, and with the putamen and the cortex. The globus pallidus receives collaterals and axons from the motor area of the cortex, and it sends a bundle of fibers, the olivary bundle, to the inferior olive and to the nucleus pontis.

The Caudate Nucleus

The caudate nucleus occupies a position beneath and lateral to the lateral ventricle. The posterior extension, or tail, of the caudate nucleus is continuous with the amygdala. Probably the olfactory impulses are partly coördinated in this ganglion. The caudate nucleus exchanges fibers with the lenticular nuclei, the anterior tubercle of the thalamus, and probably it receives collaterals and axons from the cortex.

The striato-thalamic fibers include fibers from both lenticular and caudate nuclei to several of the thalamic, hypothalamic and other interbrain and midbrain centers, both of the same and of the opposite sides.

The Optic Thalamus

The optic thalamus is developed from the second cerebral vesicle, and is a part of the interbrain. It includes many centers of varying functions and relationships. Probably the fact of the various connections and functions of the thalamus is the reason why such various and often contradictory accounts are given in both experimental and clinical data concerning this body. It is evident that with many centers of varying functions the clinical evidence and the experiments which do not recognize the subdivisions could hardly be expected to harmonize. The description given by Nissl includes twenty different thalamic nuclei. These may be grouped, for convenience sake, into the median, lateral, ventral and posterior nuclei, the nucleus of the anterior tubercle, the pulvinar, the nucleus habenulæ, and the internal and external geniculate bodies. The relationships of these may be briefly given. In the first place, each of these centers probably exchanges axons or collaterals from each of the others, both of the same and of the opposite sides. With the exception of the nucleus of the anterior tubercle, the gray matter of each nucleus is more or less continuous with neighboring nuclei. Thus the difficulty of describing the nuclei as separate centers is apparent. The nuclei seem to be all associated with the corpora striata of both sides. This relationship is more intimate in some cases than in others. The nuclei of the thalamus seem to exchange fibers with almost or quite all of the primary sensory areas, and probably of all areas of the cortex.

The individual connections of the thalamic nuclei have been described in part as follows:

The lateral nucleus receives the fibers of the lateral fillet, the spino-thalamic tract, and the fibers from some of the lower centers concerned in the common sensory conduction path. It transmits the impulses concerned in the sensations called common sensory to the cortex of the parietal lobe, chiefly the postcentral gyrus and the neighboring cortical areas. Descending fibers from the same areas are carried to the lateral nucleus.

The ventral nucleus sends fibers to the insula and the operculum, and to the region which bounds the Sylvian or lateral fissure. It also receives fibers from these areas.

The median nucleus receives fibers from the insula, the second and third frontal gyri, and the neighboring areas. It sends fibers to these areas also. It seems to be chiefly a descending path for the impulses concerned in written or spoken speech. Injuries of the thalamus are sometimes associated with peculiarities of speech, not resembling aphasia. The median nucleus sends fibers to the same areas.

The posterior nucleus lies between the internal and the external geniculate bodies. It is associated with the cortical area between the visual and the auditory overflow areas. Fibers pass both to and from the cortex.

The external geniculate body receives the fibers of the optic tract, together with the pulvinar, and transmits the impulses carried by these fibers to the primary visual area in the occipital lobe. Descending fibers from the large pyramidal and stellate cells of the primary visual area enter the external geniculate body.

The pulvinar receives also the optic tract fibers, and transmits visual impulses to the visual cortex. The gray matter of the pulvinar and the external geniculate body is continuous.

The internal geniculate body receives the fibers of the lateral fillet, and transmits the auditory impulses carried thereby to the primary auditory area of the first and perhaps the second temporal gyri. Descending fibers from the same and probably neighboring areas are carried to the internal geniculate body, and to the posterior quadrigeminates.

The anterior tubercle of the thalamus is concerned in the reflex actions, and probably also the instinctive and emotional reactions, following olfactory impulses. By means of the fornix, the corpora mammillaria and the fasciculus mammillaria the olfactory cortex is related to the nucleus of the anterior tubercle and to the gray matter around the aqueduct. This center sends impulses to the viscero-motor centers of the medulla, pons and midbrain, and probably indirectly to the viscero-motor centers of the cord.

The ganglion habenulæ receives the fibers of the medullary striæ, which transmit the olfactory impulses to the habenulæ. This center sends impulses by way of the fasciculus retroflexus to the interpeduncular ganglion, which in turn transmits impulses to the nuclei of the motor cranial and spinal nerves.

Other masses of gray matter in and upon the surface of the thalamus have been described, but not fully enough for any conclusions to be drawn concerning their functions or relationships.

Other Centers

The substantia nigra, hypothalamic nuclei and the red nucleus may be described together in this connection. All receive collaterals or axons from the cortex, especially the prefrontal, frontal and temporal lobes. All receive fibers from the thalamus, striatum, and other ganglionar centers of the cerebrum; each exchanges fibers with the others, and each sends fibers to the nucleus pontis and perhaps also to the cerebellum directly.

The red nucleus receives fibers from the nucleus dentatus of the cerebellum, and sends fibers to the lateral nucleus of the thalamus. It is thus part of the indirect sensory conduction path. The red nucleus thus appears to be an important station both in the motor and the sensory paths. It is also, probably because of this double relationship, an important center for the coördination of the instinctive and emotional reactions.

The interpeduncular ganglion receives fibers from the red nucleus, substantia nigra, hypothalamic nuclei and the cortex, either directly or indirectly. The fibers from this ganglion pass to the motor nuclei of the cranial and spinal nerves. The ganglion is thus mainly a part of the descending pathway.

The gray matter around the aqueduct includes nerve cells whose axons descend near the rubro-spinal tract to enter the viscero-motor centers, chiefly of the medulla and pons, but also, probably, of the cord and the midbrain.

Other centers of the basal region have been described by different authors. The nuclei and centers of the pons, medulla, cerebellum and cord are concerned in the transmission and coördination of the motor impulses resulting from the activity of the cortical and the ganglionar centers of the cerebrum.

Experimental Stimulation

Experimental stimulation of the ganglionar centers causes various reactions. It is not possible to locate exactly the centers stimulated by the electrodes in animals so small as cats, dogs, guinea pigs and white rats. (These are the only animals subjected to these tests in the Pacific College Laboratory of Physiology.) The animals were anesthetized before the skull was opened. Stimulation of the region of the red nucleus gave rise to movements resembling those of the normal animal when angered. The arching back and tail, the spitting of the cat or growling of the dog, the clawing and fighting movements, illustrated very well the expressions of anger. The stimulation of the median nucleus of the thalamus and of the subthalamic region gave practically the same results. When the animal had been kept under the anesthetic for too long a time, or after the stimulation had been too long continued, or when the animal subject to the test was sick or starved, the reactions were sometimes rather characteristic of fear than of anger. (Stray and half-starved animals and those which are sick are often sent to us for speedy and easy death.)

Stimulation of the same centers increases the heart beat and apparently the blood pressure. The gall bladder may be emptied into the intestine. The peristaltic movements of the stomach and intestines are usually increased by the same stimulation. No other manifestations of emotional states than fear and anger were observed.

Functions of the Ganglionar Centers

These facts are in harmony with the effects of certain emotional states upon physiological conditions. According to Mayer, Pawlow and others, it is the emotional or affective states of pleasure, desire, etc., which cause the increased glandular activities in the so-called "psychic" secretions. Cannon and De la Paz, at Harvard, have shown that in the cat fright increases the secretion of the adrenals. The presence of bile in the circulating blood after fright or anger is well known. The increased secretion of tears in grief, laughter and other emotional states is due to the activities of the ganglionar centers.

Lesions

Lesions of these centers cause various symptoms. Lesions of the striate bodies are associated usually with paralysis, due to the involvement of the internal capsule. Lesions involving the nuclei of the striate bodies alone either have not been described, or no symptoms referable to the injured part were noted before death. Lesions of the thalamus give various symptoms. Authors do not agree very well. Dejerine gives the thalamic syndrome as including paresthesias, lack of coördination of delicate movements, probably including speech, and an emotional instability or a loss of the emotional reactions.

Thalamic Lesions

Dana recognizes three groups of symptoms from thalamic lesion: First, disturbance of the intelligence due to the general effects of brain injury; second, symptoms due to pressure upon adjoining parts, or their involvement in the lesion; third, those due to the thalamic injury itself. The general symptoms vary according to the individual, and have little bearing upon the question of localization. The pressure symptoms include hemiplegia, due to the injury of the internal capsule. Dana's cases include pupillary disturbances and paralysis of reflexes, but not the disturbances of the eye movements, the forced movements of the body, the choreic and athetoid movements described by other observers. Dana finds the most definite symptoms connected with injury to the thalamus to be central pain, some anesthesia, and perhaps hemianopsia. The two latter may be due to extrathalamic lesion. Dana considers that some of his cases indicate an effect produced upon the visceral centers and the temperature of the body.

The pain involves the paralyzed side only; it involves the arms and hands most, the leg and foot next, and rarely the head. The peripheral parts cause most distress — that is, the hands and feet are more painful than arms and legs. The pain is not like ordinary pain, but is a sort of burring discomfort, more distressing than sharp or aching pain. Even when the pain itself seems only slight it causes great annoyance.

In none of his cases was there any paralysis of the emotional expressions, or any decided explosions of laughter or crying, unless there were symptoms involving other parts of the brain. Dana agrees with Roussy, who believes that the thalamus itself does not control the emotional reactions. He agrees also with Meynert, who considers the thalamus the organ which receives sensations and registers them in consciousness. The lesions as described involve the lateral nucleus, but not the subthalamic region.

The extreme complexity of the relationships existing between the various ganglionar centers of the cerebrum probably accounts for the lack of symptoms referable to the lack of activity of these centers; that is, the lack of function of one might be scarcely noticed if the other centers were able to perform their duties in a normal manner. The lack of emotional reactions does not arouse attention in as great degree as the excess of such reactions, especially when the person attending the patient has not been associated with him during his normal periods. Post mortem records of lesions of these centers, with accounts of the symptoms preceding death, rarely give any exact account of the location of the lesion. It is greatly needed that more exact descriptions of the location of lesions should be given.

The reactions characteristic of the emotional states and the reactions called instinctive are, at least in part, governed by the ganglionar centers. The consciousness of the emotional or affective states is due to several factors: First, the conditions responsible for the emotional state are usually a matter of consciousness; second, the visceral and somatic reactions as they are being performed are made conscious.

Phylogeny of the Ganglionar Functions

The development of the emotional reactions is lost in the beginnings of life itself. The securing of foods and the resistance of the attacks of enemies make up the sum total of the activities of the lower animals. The taking up of food materials from the surrounding fluids is a process which greatly resembles the union of atoms, at least in a superficial manner. It may be that the assimilation of food is, indeed, a matter of the affinity of the molecules of the biogen for certain atoms or radicals capable of being used as sources of energy, but this is a matter of theory only.

Certainly the reactions concerned in the life processes of cells seem to indicate that the use of the food materials of the surroundings is largely a matter of chemical attraction. The use of foods probably represents the beginning of the complex metabolism reactions which underlie the more complex activities necessary to the seeking of foods by the higher organisms. In seeking foods, a process made necessary by the development of organisms of complex structure, the function of the nervous system comes prominently into play. The actions concerned in this process necessitate the resistance to attack.

Positive chemotaxis may represent the beginning of food seeking; the attraction of the foodstuffs may represent the beginnings of sex attraction, such as is displayed in the union of parameciums, and the beginnings of the sum of what are included in the terms friendship, love, patriotism, and all the feelings we have for beautiful, and admirable, and desirable things. Negative chemotaxis, then, must represent the beginnings of the repulsion which the simple organisms exert toward those things in their neighborhood which are harmful or merely useless. This repulsion affects those organisms also which are harmful, or which may be merely useless. The chemical configurations of the living molecules or biogens probably are of a certain structure, and the structures of different biogens should account for the different reactions of the different organisms. From this negative chemotaxis of the unicellular organism to the sum of the negative chemotaxis of the cells of the multicellular organism there is never any exact line to be drawn. It would certainly be an unwarranted conclusion that atoms "hate" one another, or that conjugating parameciums "love" one another, as it is an unwarranted conclusion that the sum of the positive chemotaxis of the cells of our own bodies represents all that there is in ourselves of loving or admiring, or our feelings of patriotism, and loyalty, and friendship. Between these limits of negative and positive chemotaxis, phototaxis, and the tropisms and other physical forces, to the complex emotional reactions of man, lie infinite gradations, but never any unpassable gulf.

During the series of changes, which can not yet be truly termed developmental processes, the reactions become more complex as the structure becomes more complex, and as increasing size and organic demands necessitate more and more variated supplies. The demands necessitated by the development of sexual reproduction modifies the nature of the reactions in the processes of constant variation and constantly acting evolutionary processes.

Anger

The activities necessitated by hunger include the chase of food and the fight of offense. The protection of the individual against the attacks of other individuals, also hungry, necessitates flight and the fight of defense. Among animals of higher types the fight is associated with the display of certain phenomena: the showing of the teeth, which has for its worth the increased ferocity of appearance as well as the increased speed of their use; the tension of the muscles, which has for its value the increased speed and energy of their contractions; the increased blood pressure, which increases both the efficiency of the muscles and of the nervous system; the protrusion of the claws, which thus are ready for attack or defense, and the inhibition of the nerve centers concerned in other reactions. The animal stimulated to the fighting reactions shows no indications of hunger, thirst, or any other physical need; he seems to suffer no pain or sense of heat or cold, nor does he seem able to see or to hear anything except the object of his attack or his defense.

Human beings suffer the same quality of inhibition under emotional stress. The angry man feels no hunger, thirst, pity, loyalty, and scarcely any sense of pain. He lacks humor or affection, and often the sense of truth is lost. The angry man is apt to say things untrue, and unjust, and disloyal, though he may be true, and honest, and faithful at all times except during anger. The cortical neurons exercise the same inhibitory effects upon the action of the emotional centers which they do upon the spinal centers. The control of the emotional centers may be secured by the lowering of the liminal value of system of neurons which relate the cortical and basal centers in function.

The feeling called anger is the consciousness aroused by the occurrence of the somatic and visceral changes produced by the action of the ganglionar centers controlling the reaction, and of the circumstances calling these activities into play. A fairly good imitation of the feeling of anger may be produced by imitating the appearance of anger, while the best appearance of anger is produced by imagining the circumstances productive of anger to be true, while the somatic reactions are imitated as nearly as possible.

Relations of Anger and Fear

When the circumstances of life are such as to render an efficient reply difficult or impossible, then the activities characteristic either of fear or of anger result. If the individual is competent to meet the emergency, the reaction resembles anger; if the individual is not competent to meet the emergency, then the reaction resembles fear.

Among human kind the same thing is true. If any person meets environmental conditions which are abhorrent to him at a time when he is tired, or overfatigued, or suffering from some exhausting and non-stimulating disease, then the tendency is for him to "give up," to display fear and a lack of urgent endeavor to correct the conditions as he finds them. He is more apt to overvalue the strength of the opposing forces than those of his own side. He is incapable of meeting the emergency, and knows it; therefore he fears. He may be merely absurdly conservative, which is a human development of fear.

But the same abhorrent conditions may meet him at another time, when he is strong and well, and with normal blood pressure and clean blood; then he reacts to the conditions with the manifestations of that power and earnestness and certainty of success which is the higher development among mankind of anger.

Hunger

The lack of food is associated with increasing restlessness or increasing irritability. The long-continued lack of food is associated with the loss of the energy required for movements, and starvation results. At first lack of food increases the irritability of the unicellular organism and of the individual cells of the multicellular organism. The presence of hunger is associated with the motor restlessness which aids in the finding of foods, in the unicellular organism. Among animals whose nervous systems are efficient, the neuron threshold is lowered by the lack of food. The motor restlessness thus initiated is helpful in the finding of food. The same thing is true among the human race. The lack of food in the fluids of the body lowers the liminal value of the neurons, so that less stimulation is required to initiate the nerve impulse. Since the neurons of the greatest specialization are first affected by the condition, it is evident that there is a certain amount of common sense in the idea that it is necessary to starve a talent in order to make a genius. Unfortunately, if talent is starved too long, a dead talent rather than a live genius results.

The very fact of the seeking of foods by any number of animals brings about two conditions: one is, that animals seeking food may themselves be sought as food; the other is, that of two animals finding the same food, only one can eat. Warfare thus results. The struggle for existence necessitates the survival of the fittest to eat. The fact that any individual uses the food in the producing of the greatest amount of energy therefrom is, in the earliest developmental stages, reason for the survival of that animal. The struggles for food or for mates, with the visceral and somatic variations, make up the reaction called anger in animals. In man the term anger is used in two senses. Anger as a form of activity includes the series of reactions, both somatic and visceral, which are associated with an attack upon some force which is, or may be, injurious or an impediment to the activities of the person attacked, or for whose sake the attack is being made. This series of phenomena may be observed in a slight degree among animals of very inferior development, even those without the nervous system. The simultaneous attack upon foodstuffs by two unicellular organisms may resemble anger, though the resemblance must be only superficial. The problem of the feelings associated with the manifestations of anger and other passions is that of consciousness in general.

Physiology of Anger

The phenomena associated with the reaction called anger have undoubted biological value. The hairs and other forms of exoskeleton are raised by the activities of the pilo-motor nerves. This makes the animal more ferocious in appearance, and also it protects him from the claws of his enemy. The contraction of the pilo-motors among man causes the phenomenon of "goose flesh." As a means of protection or of causing a more ferocious appearance, this reaction is of very little biological value among mankind. The lips are raised and the teeth protruded. This is the beginning of the attack, and it also causes the more ferocious appearance. The pupils are dilated; the eyes thus seem larger, and sight may be made more acute. The blood pressure becomes higher through the increase in the heart's action, and the energy of the contracting muscles is greater because of the increased blood supply. The peristalsis of stomach and intestines are lessened, the kidneys secrete less freely, the glands of the body secrete less freely, except the sweat and salivary glands, whose secretion is, among certain animals, a mode of defense. The "frothing at the mouth" of the insanely angry has this significance, as has also the free perspiration associated with certain conditions of anger. Among men, also, a difference of the circulation is noted during anger.

While the blood pressure is higher by the increased heart's action, the splanchnic vessels are contracted. By this means the blood pressure is increased also, and the blood is diverted to the skeletal muscles, where it is needed during the fight. If the stimulation continues and the storm increases, the activities of the vaso-constrictor center are increased, and the peripheral vessels also are contracted. In the first instance the face and hands of the angry person are red, but during the more ferocious stimulation the face and hands become white. So the white anger represents usually the more intense reaction. This varies to a certain extent among individuals.

Consciousness of Anger

The term anger is also applied to the feeling. Anger in this sense is the consciousness of the visceral and somatic activities, plus the consciousness of the conditions which initiated the reactions. Anger does not result from the recognition of the conditions, no matter how abhorrent, which do not have any personal effect. The interference with the liberties of a neighbor affect us, because he is our neighbor; but people do not become angry in any marked degree on account of the injury or the slavery of people with whom one has no relationship. It is true that relationship may be of many degrees, and that by the multiplication of methods of intercourse the term neighbor is beginning to include many who would have been strangers in the older times.

With the development of the intermediate areas the phenomena included in the term anger becomes more or less dissociated and the elements recombined, both in reactions and in consciousness. As a result, instead of the simple manifestations of attacking and of repelling attacks, of employing the fight as an agent for the securing of foods or of mates, among men the same forces are employed in slightly different manners, with great increase in the efficiency of human effort.

The recognition of an impediment to the motor activities of certain animals leads to a manifestation of anger, and to the movements of destruction and attack. Among men, the recognition of an impediment to activities leads, or should lead, to a study of the nature of the impediment, with a view to its efficient and speedy removal. Among savages, as among animals, the immediate and angry attack is the result of unwelcome deeds or words of other persons or animals, and the fight thus initiated is apt to be very destructive and ferocious. Among civilized people the occurrence of unwelcome deeds or words on the part of acquaintances should lead to the inhibition of any reaction, until the action of the intermediate areas, the recollection of past deeds and words, and perhaps further sensory impulses of sight and sound, may affect the nature of the ultimate reaction. It may be that this postponement of the reaction will increase the vigor and destructiveness of that expression of anger, but more often the proper appreciation of the surroundings inhibits altogether the angry reaction, and much destruction is prevented.

Value of Anger

The proper appreciation of the surroundings which lead to the beginning of anger may result in determining a new mode of activity. The existence of an impediment to the activities of a normal person may lead him to endeavor to remove the obstacle. If a river impedes his progress, he may bridge the river. If a strip of land prevents the sailing of his vessels from one ocean to another, he may dig a canal across the isthmus. If things are too far away for him to see them clearly, he may make himself magnifying lenses and other instruments. If he is very much in earnest about finishing any piece of work, the increased blood pressure, the contracted muscles of mastication, the shortened breath, the tension of the lips, all show the resemblance to the primeval anger which met an obstacle. The manifestation of urgent endeavor is associated with the phenomena of anger, whose elements are isolated and recombined in a manner which makes for increased efficiency and wisdom of reaction.

Thus anger and the reactions associated with the adverse environment may be made a source of power. What is ordinarily called force of character depends largely upon the manner in which the occurrence of adverse environmental conditions affects the individual. Efficiency, self-control, the control of others, the power of attainment in any line, ambition in its best as well as in its unadmirable sense, all these depend upon the dissociation and recombination of the forces concerned in the series of activities called anger.

Fear

Fear as a series of reactions to impending attack includes both somatic and visceral changes. The feeling of fear is the consciousness of these somatic and visceral changes, plus the consciousness of the circumstances to which the reactions are due. The last factor in the feeling of fear may be absent, as in the fear present when awakening from nightmare. The somatic changes are such as adapt the body to concealment or to flight. The motor centers are wholly or in part inhibited. The body thus becomes relaxed. Among certain animals this relaxation is so complete as to cause feigned death. The animals thus affected by fear are saved from the attacks of other animals who refuse to eat food found dead. The complete relaxation causes complete quiet, so that such animals may be unseen by their enemies. The inhibition of the motor centers may be partial, as in the case of the "lame" quail, with which many children are familiar.

The visceral manifestations of fear are such as lessen the injury about to be inflicted. The sweat glands usually increase in activity. This lessens the efficiency of the claws of the attacking animal. The pilo-motors are increased in activity, and the hairs, feathers, and other forms of exoskeleton become erect. Thus the claws, etc., of the enemy are less efficient than otherwise. The peripheral blood vessels are contracted, and thus the danger of bleeding is lessened. The heart is increased in activity and the blood pressure is raised, partly as the result of the peripheral constriction and partly as the result of the increased heart action. The efficiency of the muscles of defense is thus increased, and the danger of the attack is lessened. Also, if flight be possible, this increased blood pressure increases the efficiency of the muscles concerned in that performance. It has lately been shown by Cannon and De la Paz, at Harvard, that fright increases the secretion of adrenalin. This probably is one factor in the rise of the blood pressure under fear. The peristalsis of the stomach and intestines is first decreased, then increased under fear, as under anger. The same thing is true of the bile ducts. Among human beings the visceral effects of fear and anger are somewhat modified by the activities of the cortical centers. This control produces irregular and often disadvantageous reactions, and the visceral effects of the emotional reactions may be decidedly serious under certain conditions. Rarely there results more than temporary disorders, unless the person so affected suffered some abnormal conditions before the occurrence of the emotional state.

Stage Fright

The reactions characteristic of fear are, like all other emotional and instinctive reactions, unmodified by the surrounding circumstances not associated with the disturbance. Thus, the phenomena of stage fright include the increased perspiration, the contraction of the pilo-motors, the partial inhibition of the motor centers, and the contraction of the peripheral vessels, which should be efficient in protecting from impending attack, even though the cause of the stage fright lies in the very fact that only friends of undoubted worth are present; in other words, the urgency of the desire to make the most perfect reply to the demands of any occasion increases the danger of stage fright and renders the apt reaction the more improbable. By the activities of the cortical centers the danger of the stage fright may be recognized; the person may prepare himself so fully for the impending demands that no incongruity between his preparation and the requirements of the occasion exist. Stage fright is then almost impossible.

Value of Fear

Fear is concerned in like manner with the forces which inhibit too urgent and immediate reaction. Too great stimulation of certain centers causes inhibition of other centers. The use of fear in its biological sense by the human race is one of the forces of the race. Not cowardly is the fear which preserves life and makes advancement possible. Not cowardly is wise conservatism. Cowardly is the fear which constantly inhibits all reaction; cowardly is the fear which refuses to accept the unity of the race, which saves one's self alone. The fear which preserves all, which leads to that inhibition which permits the association of the impulses concerned in memories and judgments, that is the fear which enters into every good judgment; which modifies every step toward advancement until it can be determined whether advancement and not retrogression is the direction in which the proposed step is taken. The development of the intermediate areas, with their unlimited powers of recombinations of the elements of experience, would lead to unlimited absurdities without the inhibitory effects of fear in its biological sense. What death is to sexual reproduction in evolution, that is what fear is to the activities of the intermediate areas in consciousness. Sexual reproduction necessitates the variations of hereditary qualities, the development of the intermediate areas necessitates the variation of experiences; death in the one case and fear in the other prevent too great variations from the accepted order, and wholly support the laws which make for steadfast, and certain, and unlimited advancement.

Horror

The feeling called horror resembles that of fear in part. The difference is due to the fact that in horror the impending danger is perceived as tending toward some other person or thing. Thus, in horror the consciousness is modified by the fact that the posterior intermediate areas are active, rather than the anterior intermediate areas. Thus, the differences between horror and fear are not apparent among animals whose cortical centers are not functional. Among people whose posterior association areas are not well developed, as in the excessively egoistic or self-centered person, the emotional states of horror and fear are almost or quite identical.

Disgust

Disgust is a feeling produced by the consciousness of increased salivary flow, reversed peristalsis, and the contraction of the pilo-motors, with more or less of increased sweat. In its most pronounced type disgust is associated with vomiting, and the preliminary symptoms of vomiting are the source of the consciousness of disgust. The feeling may be aroused by the presence of conditions not directly related to the digestive tract, as in the consideration of repulsive acts, unethical or immoral actions, etc. The word disgusting is used improperly as applied to conditions of loss, failure, and the like, unless some factor associated with physical repulsion be present. Disgust as applied to the acts of others is not present when these acts are considered in an impersonal manner. The most abhorrent crimes arouse no feelings of any kind in the person who studies those crimes in the effort to determine their causes scientifically and with the view of adding to the knowledge which is to prevent crime in the future.

Sex Instincts

The psychology of sex has been studied thoroughly by Havelock Ellis. Any attempt at a résumé of his five volumes would be beyond allowable limits. For a discussion of the psychical phenomena associated with sexual manifestations recourse must be had to his studies. For the present purpose it is necessary only to suggest the basic nature of the phenomena which lie at the very beginning of all advancement of the race. For by asexual reproduction no opportunity, or at least very little opportunity, is found for variation. With sexual reproduction begins the possibility of endless variations of the hereditary traits, and, as a result of this variation, the possibilities of survivals and deaths by means of which the development of the races become assured. Sexual reproduction means sexual selection, and, through this selection in its widest meaning, the selection of those qualities which make for advancement. The sexual psychology, then, must underlie much of what we are ordinarily pleased to think of as pertaining to things higher than the physical. As the sensory impulses reaching the primary sensory areas may be combined and interpreted through the activity of the overflow areas, and the significances and memories thus brought into being again combined through the activity of the intermediate areas into abstractions and ideals and prophecies for future grandeur, so the basic principles of the elements of sexual selection may be dissociated from one another and from physical reproduction, and the elements of choice, and pleasure, and admiration may be recombined and again dissociated.

The decisions made in this way may be variously affected by the associational processes, until a series of ideals and concepts arises from which all that is fine in art, and music, and architecture, and education have been developed. All that is admirable in social life, and much of the enthusiasm and joy of living, have thus been made a part of consciousness, and form a large, and important, and admirable part of daily life.

Limitations of Instincts

The laws acting through the ages, which make for the persistence of constantly higher types, of constantly more complex structure, constantly able to make greater and more economic use of natural forces, are efficient in storing within the nervous systems of the higher animals those reactions which are for the good of the race in the ordinary environment of the race. No account is taken, in the development of the instinctive and emotional reactions, of the possibility of the exceptional cases, either of the individual or of his environment. Thus instinctive reactions are perfectly adapted to ordinary cases; indeed, the instinctive reactions appear to surpass in wisdom and perfection the most thoroughly studied voluntary actions. But the instinctive reactions fail in the exceptional cases.

The limits of the value of the emotional and instinctive reactions lies in this, that these reactions are apt to fail in wisdom in the exceptional cases. It is true that often they do not fail in the exceptional cases, and that persons often do "instinctively" the things which are decidedly wise and fortunate in the exceptional cases. But such conditions are themselves exceptional. Under the exceptional cases the activities of the cortical neurons are preëminently the efficient sources of the associational and volitional impulses upon which wise reactions must depend.

CHAPTER VII

THE DEVELOPMENT OF THE CORTICAL CO-ORDINATIONS

The Function of the Cortex

The great value of the cortical coördinations lies in the fact that the exceptional occurrences may be met by appropriate answers. The reactions which occur as the result of racial inheritances and developmental processes can take no account of the exceptional cases. The projection of the sensory and motor impulses upon the widespread cortical area, with the infinitely complex fibers and tracts which relate its every part, either directly or indirectly, to every other part, makes it possible for those complex coördinations to occur which are needful for the determination of an efficient reply to the exceptional cases.

By means of the activities of the intermediate areas, with the inhibitions which become possible through the presence of the complex structure of the cortex and the manifold interneuronic connections, the factors of any experience may be dissociated, and the elements of that experience associated with other elements of other experiences, and so on. Thus, the impulses associated with any given series of experiences may serve as a basis upon which may be built other experiences, which, though never present in the history of the individual, may serve him as sources of information, and may modify his reactions as efficiently as if they had been actual experiences.

This power of dissociating and recombining the elements of actual experiences into new and imaginary experiences, which may act as determining forces in answering the exceptional demands, is the function of the cortical areas.

The Physiological Basis of Reason

The simplest form of coördination is that found in the action of the centers in the spinal cord, and the homologous centers of the medulla, pons and midbrain. In these centers the nerve cells act according to the impulses reaching them: (*a*) from the sensory fibers of the same and adjacent spinal segments, (*b*) from association cells of the same and adjacent spinal segments, (*c*) from higher nerve centers. The manner of reaction of the spinal centers is affected also by the physiological condition of the cells themselves.

The various visceral centers of the medulla and pons exemplify the next higher group of coördinating neurons. These centers receive impulses from the sensory neurons of the second order, the nucleus gracilis and nucleus cuneatus, the nuclei of the cranial sensory nerves, and from the higher centers. These centers—heart, respiratory, vaso-motor, etc.—are affected also by the character of the blood circulating through them. The higher development, the more elaborate functioning of the bulbar and pontine centers, depends upon this, that they coördinate the impulses governing a very large part of the body.

Ganglionar Centers

The different centers of the basal ganglia display a still more elaborate form of coördination. In these ganglia the coördination depends upon the receipt by them of the impulses from sensory neurons of higher than second orders. In these ganglia the results of the past experiences of the race have affected the relations of the neurons concerned in such a manner that the very appearance of danger in the environment initiates the motor impulses expressive of what in our own consciousness is called fear or anger. In the same way, the receiving by these centers of the impulses of bodily well-being, of comfortable environmental factors, initiates the discharge by these centers of the motor impulses which express what we call pleasure or satisfaction. This relationship between the environmental factors and the condition of the body has been established through ages of experiences. For those ancestors whose coördinating centers were so constructed as to secure the manifestations of fear in the presence of danger beyond the powers of resistance, or the manifestations of anger and the fighting reactions in the presence of danger which might result in victorious combat, were those whose descendants, transmitting that cause of strength, were most numerous and most ready to make use of that strength for the perpetuation of their characteristics.

The activity of the centers concerned in the instinctive or emotional reactions, as they are variously called, depends upon the inheritance of those structural qualifications which have, in the history of the race, been found to be beneficial. While there is no reason to believe that there is any inheritance of those characteristics which result from the life history of the individual, there is great reason for the belief that there is an inheritance of those qualities which modify the reaction of the individual; in other words, the history itself is not a matter of inheritance, but the qualities which enable the individual to modify his history are inherited. In this sense, then, the ganglia in which are coördinated the emotional reactions retain a racial memory; that is, the manner of the ultimate motor impulses from these ganglia depends upon: (*a*) the sensory impulses, (*b*) the impulses from higher centers, mostly inhibitory, (*c*) the physiological conditions of the neurons concerned, (*d*) the racial memories as laid down in structural and physiological relationships.

Relations of Centers

The higher centers differ from the lower in the increasing complexity of the reactions which are coördinated by them, and not in the increasing complexity of the impulses reaching them. The spinal centers are affected by impulses from the sensory nerves of the same and adjoining segments, and also by the impulses reaching them from the higher centers. The higher centers are themselves affected by impulses from over all the body; so the spinal centers may be affected indirectly by impulses from the entire body. Thus, ultimately, the origins of the impulses affecting the spinal centers are as varied and as complex as are the origins of the impulses affecting the cortical centers. But the reactions controlled by the spinal centers are comparatively simple, while the reactions controlled by the ganglionar centers and the cortical centers of the cerebrum are almost of infinite variety.

The projection of the sensory impulses upon the cerebral cortex is associated with the development of the overflow areas. The visual area occupies the lingual and cuneate gyri, the auditory area occupies the first and perhaps part of the second temporal lobe, the somesthetic area occupies the postcentral gyrus, the olfactory area spreads over the inferior aspect of the brain, involving a number of cortical areas, and the motor area occupies the precentral gyrus.

Overflow Areas

Probably in part during the development of the centers just enumerated, but chiefly since their fixed representation upon the cortex, there have been developed certain other areas in their immediate neighborhood. The primary sensory and motor areas lie upon the cortex like islands. Not one is continuous with any other, except the primary motor with the somesthetic areas. Thus, between the primary areas lie areas which seem, in animals, to have no known function.

The term "overflow area" should suggest the picture of nerve impulses reaching the primary area and flowing over into the adjacent cortical regions. Since the areas neighboring upon any primary sensory area are of greater extent than the primary area itself, it is evident that the possibilities of association processes are increased by the presence of the overflows. There are also certain peculiarities of the cell structure of the overflow areas which increase their capacity for associating and for holding in escrow the effects of the stimulations reaching the primary areas.

With the development of the overflow areas associated with the primary sense areas, the retention of the effects of the stimulation of certain neuron groups is possible. The physiological effect of the stimulation of any neuron or neuron group is the lowering of the liminal value of that neuron or neuron group. The stimulation of any neuron causes the initiation of a cellulipetal impulse over the axon of that neuron, and this impulse affects the neurons with which the axon forms synapses. If the axon forms synapses with a number of neurons, that one will be affected most which has the lowest liminal value. Thus, the stimulation of several neurons in series is associated with a lowering liminal value of the series, and the later stimulation of any neuron in that series is apt to cause the stimulation of the other neurons of the series. This is the physiological basis of memory. The question as to whether anything is ever forgotten, whether memories are stored in some "sub-conscious" reservoir, is puerile. The physiological condition of the neurons concerned is changed, but whether it is possible for the effect thus produced to be completely lost or not is something beyond the human power to determine. Are the fog drops lost when the sun shines brightly? Are the effects of the waves on the sand lost when the tide flows over them? In a philosophical sense nothing is lost; the fog of this morning, the last year's bird song, the color of yesterday's sunset, have place to-day in the effects of their past existence. In such a sense memories are existent, and in none other. As experiences affect the physiological conditions of neurons, the effects of all experiences are, in a certain sense, not lost during life. But it seems scarcely probable that the experiences of a lifetime should remain capable of stimulating the neurons concerned in affecting consciousness during a lifetime. Yet it is not possible to determine what experiences are completely lost and what are merely not recalled.

Interpretation of Experiences

By means of the overflow areas the elements of experiences are stored, and by the repeated activities of the neurons of these cortical areas elements may be dissociated and recombined, and thus new images may be produced in consciousness. These new images, the result of the dissociation and recombination of elements of past experiences, may be recognized as being part of actual experiences, at times, and under slightly abnormal conditions. The power to dissociate and recombine is a necessary element in the processes underlying intellectual life. Imbeciles fail in this power. The wonderful memory of imbeciles is due to this lack of dissociation. The increased power of dissociation and recombination is found among people of increased imagination. When this power is associated with a high degree of functional activity on the part of the posterior intermediate area, such persons are those of great mentality.

Intermediate Co-ordinations

The development of the overflow areas precedes the development of the intermediate areas. By means of the activities of the intermediate areas, the memories, the dissociated ideas, and the abstractions resulting from the dissociations of the elements of past experiences are combined into the higher conclusions, the abstract judgments, the classification of the facts and the interpretation of things as perceived in the light of many relationships. By the activities of the intermediate areas hypotheses are formed, deductions are drawn, the relationships of environmental factors are perceived in their wider aspects, and the relation of the individual to his fellow man is decided upon in the light of the wisdom and understanding resulting from the activities of all parts of the cortex.

Anterior Intermediate Areas

The anterior intermediate area is that last developed, so far as we are now able to determine. It seems, then, that at present the most complex activity of the cortical centers is that concerned in the proper correlation of the individual to his environment. The whole value of all the processes concerned in consciousness is to modify man's behavior in the midst of the world in which he is placed.

The Right Hemisphere

The intermediate areas of the right hemisphere and parts of the left hemisphere have not yet become developed, so far as our present knowledge goes. What psychological conclusions may be drawn from the lack of function of these areas we are not now in a position to say. Speculation is easy and safe, since there is no way to demonstrate the falsity of any speculations concerning things which are not known.

Phylogeny of Intelligence

It is impossible to describe the phylogeny of intellectual attainments in any exact manner, since our accounts of the racial development are extremely imperfect. The first chapters are lost, and we do not even know how many are lost. The paleolithic man had fire, implements of stone, and a certain degree of skill in forming these implements. Cities have been uncovered concerning which the inhabitants of the region have no knowledge, and beneath these, built upon ruins imbedded in the slow drifting of the dust, are found other cities, and others still deeper, and these, even, have shown the use of metals, and the dishes and implements found show much skill and artistic merit in form and workmanship. The Egyptians had attained a high degree of civilization before they built the pyramids, and their scientific attainments were considerable, at least in physics and astronomy. So, in history, the first chapters of intellectual development are lost.

Difficulties

In the study of the racial development of the human brain one difficulty is met which is perfectly avoidable. Anthropologists measure the skulls of prehistoric peoples with much accuracy from the outside. But these measurements do not indicate the size or shape of the brain with any accuracy at all. If the skulls found could be measured from the inside, or, better, if casts were made of the inside of each skull, our knowledge of the development of the brain during racial progress would be increased. The skulls vary in thickness of the bone and in the size of the various sinuses. These variations are sufficient, in skulls of present peoples, to invalidate any but the most rude conclusions concerning brain development. It may safely be concluded, then, that the same conditions are met in the prehistoric skulls.

Significance of Myths

In myths and traditions some inkling of the beginning of intellectual development may be found. The truth of the conclusions drawn from the study of myths seems fairly apparent when the myths of distant countries and of races not known to be related are compared. They are found to display very marked resemblances, and these resemblances include the factors which appear to be most significant in explaining, or at least in illustrating, the phylogenetic development in function of the intermediate areas.

Visual images seem to be considered, for the most part, as commonplace; auditory images are given more attention. The fact that the projection of auditory images upon the cortex followed the projection of the visual images is of interest in this connection. The auditory radiations become medullated at a later time than the optic radiations also. Thus, it is probable that the auditory overflow is of later development, both phylogenetically and ontogenetically, than the visual overflow. Savages dream of sights, but rarely of sounds, and they attribute greater significance to the things heard in dreams than they do to things seen.

The great significance attached to the naming of things is of interest in this connection. The naming of objects, of ideas, the exact expression of things seen, and thought, and felt in language, is one of the most important factors in education to this day. In myths the relationship is recognized. The monster named was the monster conquered, the fairy named was made to serve, the good quality named was compelled to wait and serve.

The conquering of evil spirits, or monsters, or powers of malicious intent by means of cunning is another idea which is found among myths. The conquering of good spirits is less often found. In these is found the characteristic of humanity to associate the ideas of the individual with what is good, and to attribute to the forces which impede him malevolent qualities. The individual is the center of his own universe; the recognition of that fact may be delayed, but the reactions based upon any other supposition meet with disaster. This characteristic of egoism is naively displayed in myths of all races.

United Action

Myths of somewhat later origin show mankind acting together against a common foe. The very oldest myths show no common humanity, but only individual triumphs. The hero, acting and saving his race or family, appears in the myths not of the most ancient. Thus, the unification of the family and of the race begins before the age of history, but at a later time than the recognition of personal bravery, or cunning in the conquering of personal foes.

No myths, save those of evidently comparatively modern times, portray individuals working together for a common end. Rarely a hero may compel his people, but the single hero is the essential characteristic of these myths.

Loyalty to ideals is never found; a doglike, habitual sort of fidelity to a person, or obedience to a command, may be found, but rarely.

Personifications

Myths are characterized by personifications. The individual is unable to attribute qualities to inanimate objects; he simply fails to see any reason for not recognizing the qualities he sees. If the storm clouds act angry, they are angry. Why not? If the waves glisten like eyes, they are the eyes of a spirit. Why not? If the grain waves like beseeching arms, it is arms beseeching. Why not? Nowadays we see resemblances, and personification is a figure of speech; in myths there is no figure of speech; the things were seen as persons and are so described; the things were heard as speaking, and are so described. The whole saying is naive and simple, like a child's tale.

The Ontogeny of Intelligence

It is true in part that the ontogeny of mental development repeats the phylogeny. The naive and simple explanation of the various natural events of the days of mythology belong to the childhood of the race. The myths are essentially child-like, though probably they could not be duplicated by the child mind of to-day; yet the stories told by children now resemble the myths in considerable degree. The explanations of the thunder, the appearance of the stars at night, the falling of the rain, all these are given by children with the same naive simplicity, the same ideas of personality and ethics, the same superficial views of cause and effect, that characterize the myths of all races. The peculiar stumbling upon truths afterward determined by scientific investigations belong to the childhood of the race, to the young children of to-day, and to those people of all races sometimes who are included under the class genius. Such stumbling and unbased coincidences are often cited as indicative of some supernatural source of knowledge possessed by children and persons of the genius type; but if the unbased statements made of such persons the world over should be placed in one list, and the facts as later determined to be true should be placed in another, it seems that the laws of coincidence would govern the situation completely. Those who assume the probability of some source of knowledge possessed by children, geniuses and some others use only those occurrences which appear to show the display of this unbased knowledge, but disregard the millions of unverified statements.

Dreams

Children and the men of the childhood of the race alike recognized a certain value in dreams. The manner in which this fallacy arises is this: The repetition of occurrences is associated with their recognition as a memory. The occurrences which are not repeated are not remembered. The dreams which are not followed by any occurrences which bring them into consciousness again are forgotten, while the dream which is followed by some occurrence which tends to bring the dream again into consciousness is remembered vividly. Thus, the dreams which come true are remembered, while those which fail to come true are forgotten. So it is easy to see why the belief in dreams should be so unfailing a characteristic of myths, of savage peoples and of children. Thus, dreams were held to be expressive of the intentions of some personality beyond waking hours. The forms of clouds and waves, the sounds of wind and falling water, the flying of birds and bees, all natural occurrences which displayed no visible cause, were taken as other expressions of the will and the desires of the unseen. Thus arose the custom of divination in its various forms. This custom also has its place in children's lives when they act without too exact oversight by pedagogical teachers or parents.

Such habits of thought are to be considered as the result of the activity of the overflow areas in the absence of very marked function of the intermediate areas. Impulses reaching the primary sense areas were coördinated in the overflow areas; the simplest possible significance was attached to things seen, heard, etc., and the interpretations thus rendered were accepted. The attainment of a really very high scientific and artistic merit is not beyond the possibilities of the activities of the overflow areas. The interpretation of facts is possible to the overflow areas, but the criticism of the interpretation is due to the activities of the intermediate areas.

The differences between the civilization of the ancient races and the civilization of modern times lies in the action of the intermediate areas. By the activities of the overflow areas abstractions were made and were personified, facts were recognized, conclusions were based upon the facts, but the conclusions were not subjected to any but the most superficial scrutiny. If any interpretation of a fact was offered, it was accepted, apparently, according to the rank of the person who offered it. Even now most of us find it difficult to judge any interpretation of observed facts without reference to the personality of the one who first offered it. It is evidence of the functional activity of the intermediate areas that one is able to view an interpretation of facts, after having verified the facts in the light of evidence, without referring to the personality of the inventor, and without referring to the prejudices or the feelings associated with the subject-matter.

The development of the coördinations in the individual must repeat in part the development of the cortical coördinations of the race.

Summary

It is to be noticed that the evolution of the cortical area has apparently progressed from the posterior toward the anterior part of the hemispheres; or, rather, that the interposition of the anterior and more lately developed centers pushed the earlier centers posteriorly. The olfactory cortex first, then the visual, then the auditory, then the somesthetic areas, all preceded the development of the overflow areas, as the development of the overflows preceded the development of the intermediate areas. The progress of psychical development in any individual probably follows the same path. The commonly-accepted view is that the psychical ideas associated with self are first appreciated, then at a later time the ideas of things distant. It seems very improbable that this is true. The olfactory cortex does not seem to have any overflow area, and the olfactory impulses do not seem to be associated with any reactions apparently conscious for quite a long time. It is true that reflexes may be associated with tastes and smells at a comparatively early time. Visual images are apparently represented first in consciousness, then auditory, then the common sensations. Volitional movements are found latest developed. Reflex actions are present from the day of birth, and these may be associated with sensory stimulation, but these reflexes are not indicative of cortical activities.

Primary Sensations

The activity of the primary sense areas is associated in consciousness with primary sensations, unassociated with past experiences, uninterpreted in any way, and not localized in relation either to the body itself or to any external condition. Probably this sensation is not to be experienced by any adult human being except under extremely abnormal conditions, and then it would not be possible to recognize the condition, since the very possibility of recognizing the experience necessitates the existence of associational processes.

The development of the overflow areas depends upon the receipt of impulses from the primary sensory areas. The activity of these areas is associated in consciousness with the recognition of past experiences, the significance of the sensory impulses received, and through the neuron groups relating the sensory overflow areas to one another, the recognition of objects as being perceived by more than one sense. The identity of the thing which is seen with the thing which is heard, or felt, or tasted becomes recognized in consciousness through the activity of these areas. The mentality underlying the age of myths and early childhood depends upon the development of the overflow, but probably not the intermediate areas of the cortex.

Since the development of the overflow areas depends upon the development of the primary sense areas, and since the development of the intermediate areas depends upon the activity of the overflow areas, it is evident that incoming sensory impulses make the foundation upon which the faculties resulting from the development of the intermediate areas can be built. During the development of the child mind the accumulation of facts is a matter of greatest importance. In the adult, taking up any new line of work, the accumulation of facts is the matter of the first consideration. In caring for those who are sick or who suffer from the psychoses it may be advantageous to develop new relationships among the cortical centers by adding new facts to the memories stored in the cortical neurons.

Upon a basis of observations is built the superstructure of what are commonly called the higher faculties. These observations are most efficient if they include the activities of as many primary sense areas as possible, and if they are related to as many motor impulses as possible.

Educational Principles

Children should, then, be taught to see things from as many viewpoints as possible, and to interpret the things seen in action and in speech — spoken, written, picture language, and by modeling, if possible. The knowledge of the surrounding country which is gained by walking around over it, by making maps, by looking over the valleys from the hilltops, and by seeing it from the standpoint of the botanist, geologist, historian, artist, farmer, and in the eyes of as many other people as possible, makes the best possible foundation for the development of individual activity in whatever line the child's characteristics lead him.

The Wider Environment

In order that a solid foundation of these primary sensory images and memories may be laid, it is best that the environment shall not be too narrow. Probably with a certain amount of guidance a valley among high mountains may serve as a wide enough field for human observation; but this narrow valley is not usually the home of either teachers or parents capable of giving such guidance. The physical outlook should be wide enough to include the possibilities of seeing things from many standpoints, and it should include in its limits enough people of various characteristics and of enough varying outlooks to make the different points of view possible. This increasing of the environment depends very largely upon the manner in which the child's life is circumscribed by his elders. Children of wealth, traveling with tutors, have probably narrower limits of contact with the world than the mountaineer, who travels at will over his little valley.

Environmental Limitations

The position of people who are limited in possibilities by limitations of environment becomes extremely pitiable when they become sick, or placed out of the conditions to which they are accustomed. The person whose outlook has been broadened has at his disposal many memories and associative possibilities by means of which he may adapt himself to new conditions; but the narrow mentality, associated with narrow environment, is unable to adapt the individual to new surroundings without much suffering and labor. This is as true of those who do not employ the possibilities of education as it is of those to whom education is denied. The wealthy person whose life processes follow a narrow pathway is as greatly injured, and cramped, and bound in by his habits as is the ignorant, and poverty-stricken, and helpless mountaineer. The child whose every thought and observation have been subjected to the critical scrutiny of his elders is not less limited in his environment than the gamin who lives by his wits in the slums. Both are equally cramped by environmental limitations, both grow into persons of limited possibilities, of narrow outlook, of undeveloped powers.

It is the duty of every physician to recognize the conditions needful for normal educational factors, and to use whatever influence he has in helping parents and teachers to provide these things for growing childhood. For the narrow grown person the physician can do much also. People have enough powers lying latent to provide for increased possibilities of development through all their lives, and new sensory impulses may be employed in the development of new association processes as long as one lives.

Development of the Intermediate Areas

The development of the overflow areas is associated with the memories and with simple interpretations. The development of the intermediate area of the parietal lobe brings the possibility of the classification of environmental facts and of the appreciation of external relationships. The later development of the anterior area brings the possibility of coördinating the facts in regard to the place of the individual himself. It is of no use to appeal to the child's ideas concerning his proper place among other children, or among the other members of his family; as well might one ask a blind man to criticise a painting. The child has no self-brain until about the age of puberty. Then he attains a rather absurd and excessive idea of himself in relation to his fellows; but the development of the neurons of this area in relationship with the development of the neurons of the posterior intermediate area is soon associated with the decrease of the absurdities.

Educational Principles

In education, the thing to do is to place the child in such a position that the habits are formed which place him right in the world, so far as manners are concerned. If he has the basis of a series of right habits, the conservatism of habit will secure him a good place to start from in his determination of his own place in the midst of things. He should start out with the habits of manner, and thinking, and use of himself which are customary among the people among whom he lives, then whatever further place he has will depend upon his individual reaction to his individual environment.

Education begins with the beginning of life. The transmission of nerve impulses from one nerve cell to another causes a lowering of the liminal value of the nerve cells concerned. The transmission of nerve impulses through any neuron series lowers the liminal value of that series. The performance of any reaction causes that reaction to be more easily performed at a later time. Every time any reaction occurs, that reaction becomes easier. Upon this physiological fact depends all of education. This is the reason for repetition in education. The liminal values of the neurons concerned is lowered until the reaction repeated becomes habitual. The teaching of little children can include practically nothing but the formation of right habits.

Obedience

The development of the habit of obedience is one which many parents insist upon. Doubtless many parents develop this virtue too greatly in their children, since too implicit obedience may lead to personal weakness in later years. But a sensible obedience is a thing which is natural to most children, unless they are spoiled by being constantly commanded to do unpleasant things. To teach obedience is usually unnecessary, for it is natural for a child to obey without question, under ordinary circumstances. The child who has become disobedient is not usually well trained to obedience by harshness. One of the best ways to deal with such children is that through repetition. He is told to do the thing which he would do anyway, but he is not compelled to do that which he dislikes. When everything he wishes to do is preceded by authoritative direction, he finds himself unable to do that which he wishes without obeying. The habit of obedience is soon secured; then rather gradually a certain amount of initiative may be permitted, and he may be told to do things which he might not find agreeable. If he obeys, well and good; if he does not obey, the dose must be repeated; he must be told to do everything which he wishes to do, without exception, until the habit of obedience is established again.

Excessive Subordination

A fault of earlier times, which does not exist to so great an extent nowadays, is the habit of maintaining parental subjection for too long a time. In olden times children whose intermediate areas were becoming developed were kept in the most implicit subordination. The impulses aroused by environmental changes were transmitted into motor impulses, not as the result of the activities of the child's own brain, but as he interpreted the probable decisions of his elders. During the last century it was not rare for the children of the most worthy parents, children of the most admirable training according to the opinions of the times, to grow into the most wicked reprobates. The maintenance of too great subjection after the intermediate areas begin to become developed is associated with the presence of antagonistic series of impulses due to the activities of these areas. The ultimate reaction is, for a time, that due to the predominant influence of the parental teachings, but with these are associated the antagonistic effects of the impulses concerned in the appreciation of the youth's own thought. The reactions chosen are thus permitted to act upon the motor overflow areas; the liminal value of the neuron systems concerned in the reactions exactly antagonistic to all his teachings is lowered day by day, until finally the time comes when he is apt to find the neuron systems concerned in the expression of his own opinions and desires more efficient than the steadily-weakening influence of the teachings of his childhood, and he is apt to follow every impulse against which his early teaching was directed.

The pendulum has swung too far in the other direction now, in some families. The children are thrown upon their own responsibility before the overflow or intermediate areas are capable of performing any duties of association or coördination. A number of avoidable errors is thus made a regrettable part of the child's experience.

Development of Character

The rational method is that indicated by the physiological development of the cortical areas. The child should not lose his tendency to obedience; if this does occur through wrong training, he should again be accustomed to the habit. This is done, as is given in another section, by telling him to do everything which he wishes to do, without exception. Let him not be able to find anything which he wishes to do, which he has not already been told to do. The habit of obedience is bound to follow, and this without any of the furious storms which usually are associated with the endeavor to compel an unwilling obedience in an obstinate, spoiled child. Such storms are harmful beyond measure, and usually the child is the real victor in the contest.

Obedience should be absolute during the earlier years. With the beginning of evidences of reasoning, the endeavor should be made to let him use this power gradually, and, without his recognizing the fact, let him do practically the same things he has been doing obediently from the effects of the activities of his own brain. The environmental changes thus initiate appropriate reactions directly, the liminal value of the neurons concerned in rational and well-chosen reactions become progressively lower, and the rational actions become fixed in the physiological condition of the cortical neurons — that is, become an integral part of his character. No antagonistic impulses are thus permitted to affect the motor overflow, since he has been led to choose the rational reaction himself, and no inhibitory neuron systems enter into the situation at all.

Obstinacy in children and in older people is the condition associated with the overactivity of the neurons of inhibition. It is probable that the inverted pyramids of Martinotti are the neurons most concerned in this reaction. Increased stimulation of the neuron series concerned stimulates the inhibitory cells all the more. The endeavor to cause obedience in the obstinate child or to limit certain crimes among grown people by the use of excessive punishments is productive of harm The attempt should be made to secure the reaction desired without the intermediation of the inhibitory neurons. This is done by giving instruction to children while their muscles are relaxed, as after they are in bed at night sleepy and tired, or at any time when they are found to be "biddable" and well. No attempt at discipline or instruction should ever be made when a child is sick, or overtired, or hungry.

Development of Personality

After puberty, when the anterior intermediate areas have become developed, the personality of the individual becomes fairly well fixed. The activities of the various intermediate areas relate his activities to the conditions of his environment and to the activities of his fellow man. The activities of the overflow areas constantly bring memories of the past events of his own life to be associated with present sensory impulses; the overflow areas also interpret the things perceived by present experiences. The activities of the intermediate areas interpret, and criticise, and modify, and control the reactions coördinated by the ganglionar centers. Deciding the propriety of any emotional reaction, he permits that emotional reaction full play, as previously decided upon. Thus life has in its emotional characteristics the force associated with the reactions controlled by the basic instinct and emotional states, but has none of the destructiveness due to the unbalanced activities of the ganglionar centers.

Inheritance

Any discussion as to the possibility of the inheritance of acquired characteristics is beyond the purpose of this paragraph. It is enough to say that the facts seem to indicate either the possibility of acquired racial characteristics, or that the forces of variations, survivals, deaths and choice act in practically the same manner in the perpetuation of certain characteristics of cerebral development. Since the inheritance of visible structural characteristics is practically proved beyond question, it may probably be granted that there is an inheritance of those structures which are not visible.

The inheritance of the structural relationships which underlie the functional relationships of the neurons is quite as much a certainty as is the inheritance of a certain form of lip or of chin, or of any other feature. The inheritance of the neuron groupings which underlie the consciousness of certain facts is thus assured. The inheritance of certain paths through the central nervous system, by means of which certain environmental changes are easily and quickly followed by certain motor reactions, is also a matter which may be granted. This inheritance is brought about, no doubt, by the same evolutionary forces, whatever they may be, which have produced the present development of the other parts of the body.

Affectional Reactions

When it occurs that any sensory impulses arouse an immediate motor reaction which includes both visceral and somatic structures, a sense of emotional states arises in consciousness. This is due to the persistence of the primitive racial characteristics. Whenever any given association process is concerned in the coördination of certain facts, as of axioms, or of what are called "higher" truths, the neuron systems concerned are those whose liminal value is the lower because of the racial experiences. Thus it is found that such truths are greeted in consciousness with a sense of acquaintance, of pleasure or distaste.

General Statements

In the progress of human development it has long been noticed that the study of the most distant objects, the stars, was the first scientific attainment of the race. This is true, to a certain extent, of all races. Many of the savage races are exceptions to the rule. Later the studies included subjects nearer at hand.

In artistic history it is found that the development of painting and sculpture preceded the development of music.

In dreams, especially among savages, the auditory images are much less distinct than are visual images. Myths show a constant tendency to attribute to auditory hallucinations a mystic force, while visual hallucinations usually are dismissed as dreams.

All of these facts are probably due to the fact that the auditory overflow becomes developed at a later time than the visual.

DEVELOPMENT OF CORTICAL CO-ORDINATIONS

Developmental Precedence

In the processes of the development of the cortical coördinations the functions of the overflow and intermediate areas follow a long way after the development of the primary areas. The progress of the race in civilization is indicative of the comparative slowness with which the attainment of anything like perfect functioning of the intermediate areas occurs. The steps in the development of the overflows follow in the order of the development of the primary areas with which they are associated. and the development of the intermediate areas follows the same steps also. Since the overflow areas for the olfactory and gustatory impulses are not recognized, it is evident that we can not determine whether the same laws are concerned in these senses as in the others or not. Of the senses whose relationships are known, at least in part, the laws a^ given seem to be true.

Phylogeny of Visual Co-ordinations

The visual area is developed first, and the visual overflow is concerned in the coördination of the visual images before the auditory areas are developed in anything like the same degree. This is shown in many ways; the characteristics of the older myths, the development of the visual ideas in the child, the comparative development of the visual functions in feeble-minded children, the facts of the phylogenetic development of the cortex, all show the greater age of the cortical projection of visual images.

Phylogeny of the Auditory Co-ordinations

The auditory impulses follow the visual, and the development of the primary motor area of the cortex appears to become efficient at about the same time. The auditory overflow area is continuous with the visual overflow area, and the development of the area intermediate between the two is completed at a somewhat later time. The comparative youth of the auditory projection upon the cortex is associated with the facts of mythology, of the development of music at a later time than the development of painting, sculpture, or architecture, all of which depend upon the visual cortex. In the average child, also, the sense of music is developed at a later time than is the sense of color or form.

The significance of things heard is developed at an earlier time than the significance of things felt, or of things as resistant to muscular effort.

Phylogeny of the Somesthetic Co-ordinations

The projection upon the cortex of the common body sensation is a matter of later development. Among savage races and among those people who have neither the time nor the energy to attend to any but the merest necessities of life, the physical senses are of great importance in modifying the daily reactions, but not in adding to conscious knowledge in great degree. This condition, present now among the very poor and among savages who live with much difficulty, is associated with no particular attention to the body sensations, except as pain impulses compel a certain degree of attention. There is some reason to believe that these people do not suffer so great pain under the exigencies of life as people of higher nervous development do. This may be, perhaps, due to the fact that individuals who do suffer die off rather early in life among those people, while only those who feel comparatively little pain endure existence for a certain time. Among civilized people, on the other hand, every effort is made to perpetuate the physically unfit.

The beginning of the development of the common sensory overflows and of the neighboring intermediate areas seems to be associated, first, with a tendency to the exaggeration of these sensations, and then with a tendency to their limitation in consciousness.

Bodily Injuries

Thus, among savages of all races and among the primitive peoples there is found the care of the body which almost amounts to worship. This tendency is associated, later, with the decoration of the body in ways which add to the sensory stimulation and to the high esteem in which the body itself is held. The process of tattooing illustrates this condition. The painful process occupies many weeks, perhaps many months and years, and yet it is done with much pleasure. The wearing of ear rings and nose rings, the slitting of the lips and cheeks for the sake of wearing jewelry and various decorations, the mutilation of sensitive parts of the body, with associated decorations or without these, all indicate the low pain threshold and the reactions charateristic of the cortex in which the common sensory areas were being developed.

Later the common sensations became sufficiently developed to fail to arouse any of these incoördinated and injurious reactions. During the developmental period of any area the attainment of function is first associated with the performance of exaggerated function, then occurs the period of lessened function with increased association impulses, then the times of completed associations, with the associated consciousness of the sensory images and the employment of these sensations in the control of the daily life processes. In the development of the cortical areas for the common sensations the period of comparative inactivity is associated with a tendency to "mortify the flesh." The people of the middle ages did this, and to this day the association of extreme goodness with bodily pain is present in the minds of most people.

That great merit is to be attained by suffering alone is one of the ideas of the primitive mind, and it depends upon the developmental processes as they occur in ontogenetic as well as phylogenetic development.

Ontogeny of Sensory Co-ordinations

Children pass first through a naive and childish stage of bodily vanity, in which, with no apparent self-consciousness, they decorate themselves with bits of bright ribbon and feathers in a savage and outlandish manner. This is usually followed, in most children, by a period of self-depreciation and especially of bodily inattention. The repugnance to the bath of this period is as pronounced as in the days of the early martyrs. Probably something of the same reason lies at the base of both peculiarities.

Later the fuller development of the common sensory overflows and the associated development of the anterior intermediate area is associated with the beginning of the extremely egotistical stage of consciousness. The body is then again a thing to be cherished and cared for, this time in the light of the most intense self-consciousness. This stage occurs at about the age of puberty, and the egotism of that period is due to the development of the anterior association areas, together with the initiation in the lower centers of those sensory impulses associated with the increased function of the sexual organs and the circulatory changes associated with this increased development.

With the attainment of the adult life the normal individual undergoes the changes in his sense of personality which are necessarily associated with the development of the coördination of impulses from other parts of the cortex with the anterior association areas. Also, the changes in neuronic function initiated by varying environmental conditions cause the activities of the anterior association areas to become modified in accordance with the greater range of associational impulses; thus the reactions become saner and the consciousness of personality assumes something like a rational development.

Present View of Sensory Impulses

At the present time, among the more highly-educated and civilized peoples, the care of the body assumes a fairly just importance in the conduct of life. The body, as a sort of complex machine, able to attend to the duties laid upon it by the activities of the cortical neurons, is beginning to be recognized as a thing to be cared for and saved, or to be mistreated and destroyed. The older ideas of diseases as entities, or as punishments sent for some strange purpose, are superseded by the newer thought, that the laws of cause and effect are as immutable inside the body as outside the body, and that the abuses of the body must be followed ultimately by a loss of usefulness.

It is true that the body is still valued, by some races and by some individuals of all races, as if its chief worth lay in its lack of usefulness and in the value of the things which can be attached to it. There are other races and other individuals among all races who still hold to the older ideas that the body is a thing to be disregarded and kept subject to the so-called "higher" faculties, or to be considered as non-existent. The best thought to-day is that which sees in the body a thing whose chief value lies in its efficiency, the strength of its muscles, the keenness of its vision, the range of its environment and the perfect coördination of the cortical neurons, upon which depend the wisdom and efficiency of the daily answers to the daily demands of living.

CHAPTER VIII

CEREBRAL LOCALIZATION, SENSORY

The part of the nervous system which is concerned in those activities perceived in consciousness is that which occupies the cerebral cortex. The cells of the cortex represent the highest development of the neuron. They are best developed in man, and they are the first sufferers when the nutrition of the nervous system is interfered with, or when poisons are found in the circulating blood. It is true that certain poisons have a selective action upon other cells of the nervous system, rather than upon the cortical neurons; but, as a rule, those abnormalities which affect the body at all, affect first the cells of the highest development, the most specialized function, and the most rapid metabolism. These cells are chiefly found within the nervous system, and the cortical neurons are most highly developed, most perfectly specialized, and most energetic in metabolic processes of all nerve cells.

Since consciousness is affected through the intermediation of the cortical neurons, it follows that, so far as our present knowledge goes, the physiology of the cortical neurons is the physiology of consciousness.

The functions of the cerebral cortex are localized to a certain extent. The motor areas are very exactly defined — so exactly that in certain cases this knowledge may be safely used in surgical procedures. The sensory areas are less exactly defined. Sight, hearing and the somesthetic areas are fairly well recognized; smell is less definitely limited upon the cortex, while there is very little known concerning the localization of taste. Other sensations seem to have no exact representation upon the cortex, so far as our present knowledge is concerned.

Development of Localization

The placing of the different functions upon the cortex rests upon some law which is not yet recognized. The beginning of the cortical representation of somatic functions is found in the olfactory cortex. The other somatic functions became represented at later periods of development, but during the development among many classes of animals the progress has followed practically identical lines, and the areas in which certain functions are represented are the same for all classes of mammals, except as the varying degrees of functional development of certain areas may be associated with certain structural variations. It is not known what relationship exists between functional development and structural relationships.

Apparently the different parts of the cortex are practically alike at early stages of ontogenetic as well as phylogenetic development. Yet areas which are practically identical become differentiated into areas of specific function, or "specific nerve energies," and these areas are practically identical for all mammals. The problem thus presented is not limited to nervous phylogeny and ontogeny, but it presents more baffling puzzles, perhaps, in regard to nervous development than in the development of the other structures of the body.

Given the placing of the primary sense areas and the primary motor areas of the cortex, the development of the other parts of the cortex seems logical enough. The areas adjacent to the primary sense areas, the overflow areas, receive the effects of the stimulation of the cells of these primary areas, and increasing complexity of neuron relationships follows naturally enough. As the result of the increased activity of the overflow areas, with the associated complexity of coördination of nerve impulses, the stimulation and development of the intermediate areas follows with equal facility.

The progressive assumption of the functions of coördination by the overflow and intermediate areas is thus a matter simply of functional relationships of the primary sensory and motor areas, and of the morphology of the cortex itself. The conditions which modify the development of the overflow and intermediate areas are apparent from the consideration of the physiological relationships. In order that the overflow areas may be well developed it is, of course, first necessary that the physiological requirements of the cells themselves for normal nutritive conditions shall be met; good blood, flowing freely under normal pressure, the efficient removal of the wastes of metabolism, no less than the efficient feeding and oxygenation of the nutrient fluids, are essential first of all to the normal development of these areas. Given these physiological requirements, the development of the primary areas depends upon their activity, and this is dependent upon their stimulation. This is accomplished by means of the sensory apparatus associated with each cortical primary area. The development of the visual cortex depends upon the nerve impulses from the retinæ; the development of the auditory cortex depends upon the impulses from the cochlea, of the somesthetic area, upon the impulses from the body, and so for each of the primary sense areas of the cortex.

The development of the overflow areas depends upon the activity of the primary areas, much as the development of the primary areas depends upon the stimulation from the sensory apparatus. As the result of the activities of the overflow areas the intermediate areas are stimulated, and their development becomes possible.

The localization of the various functions of the intermediate and overflow areas thus depends upon the structural and functional relationships of the primary sensory and motor areas.

Localization of Overflow Areas

There is thus a certain localization of the associative memories upon the cerebral cortex. The "overflow" areas of the sensory and motor areas are functional in retaining within themselves, probably as the result of variations in their functional activity, the effects of any given stimulation. The effects produced upon these cells by stimulation seem to be peculiarly far-reaching, so that subsequent stimulation in much less degree suffices to cause the same or similar activity to occur again. The activity thus initiated is associated with the conscious phenomenon called memory. Memory is the consciousness associated with the activity of neurons which repeat metabolic changes. The overflow areas are especially adapted to the retention of the effects of metabolic changes, probably partly because of their structural and physiological characteristics, and partly because the overflow is larger than the primary area, and contains cells variously related to the cells of the primary area. The overflow areas are thus concerned in the associative memories of the activities of the adjacent primary area.

Between the overflow areas there appear other areas which give no response to cortical stimulation in animals, and whose injury does not produce any marked symptoms in persons who are of deficient mentality, or whose powers of classification are not well developed, whether they are not capable of education, or whether they merely have failed to receive education, in the broader sense.

These areas have been called "negative areas" or "silent areas" for these reasons. It is probable that the term "intermediate areas" is better, since this morphological term has no psychological significance. There is reason to believe that these areas are capable of performing certain functions when the demands of the higher civilization are made upon the individual. Probably no person uses all of these areas. If the part of the cortex which is unused by a certain person should be injured, no localizing symptoms would follow the injury. But another person, in whom those particular cells might happen to be well developed, suffering from that same injury, would lose a large proportion of his powers of mentality, might become insane, in fact. The fact that certain parts of the brain remain unused, probably throughout life, accounts for the different results of brain injuries and diseases. The following cases illustrate the possibility of serious brain lesions without recognizable localizing symptoms:

Localization of Lesions

Sachs and Berg, *Medical Record,* January 23, 1909:

Case of otitic brain abscess in woman. Symptoms were, first headache, nausea and vomiting, not projectile. After that she seemed more talkative than usual, but always apparently rational. About two weeks later she complained of headache, and that day seemed to have forgotten the names of the people in her home. She seemed able to talk freely enough, but was unable to understand things said to her. There was at that time slight rigidity of the neck, some right facial paralysis, some weakness of right leg and arm. On the third day after this there was found some paraphasia, but she was able to speak fairly well; she was not able to understand the meaning of questions or commands. There was headache and some somnolence. At operation an abscess containing more than two ounces of pus was found about an inch below the surface of the left temporo-sphenoidal lobe.

R. D. Rudolph gave this case report before the Association of American Physicians, Washington, D. C., 1909:

Woman of 46; symptoms had been those of neurasthenia. There were "compression attacks" during the last six months of her life. These were accompanied or preceded by blood-pressure rise from about 120, the normal, to 200. The attacks were characterized by vomiting and profound coma. She died in one of these attacks. At autopsy two tumors were found, one growing from the pia mater over the left occipital lobe, the other over the left brain just behind the ascending parietal convolution. There were no localizing symptoms at any time.

Sachs, at the same meeting, gave this report:

A patient, a young man, had attacks of convulsive seizures at intervals of three or four months. There were no other symptoms. He died suddenly, and at the autopsy a large glioma was found occupying almost the entire left hemisphere. It seemed hardly possible that no symptoms should have appeared, The glioma had grown very slowly.

Many other cases are recorded. Injuries slowly produced may be associated with compensatory activity of other parts of the cortex.

For the most part, however, the clinic records seem to indicate that injury of any part of the brain is followed by a loss of the function associated with that part of the brain. The lesions found associated with those parts of the brain of more general function, and lesions of parts of areas of broad extent, give symptoms of less exact localizing significance than do lesions of small and definitely-located functional areas. The functions which are performed by areas of broad cortical extent are, for the most part, those of the earlier phylogenetic development. The olfactory cortex is one of these areas.

The lack of localizing symptoms in cortical or ganglionar lesions is due sometimes to the existence of pressure symptoms. The growth of a tumor in any part of the brain increases the intracranial pressure and lessens the blood supply to the entire brain. The pressure and the lack of nutrition affect the functions of practically the entire nervous system, since the abnormal condition of the brain affects the spinal centers to a certain extent. Thus, the most prominent symptoms of brain lesions may be characteristic of no particular area, and there may be even nothing indicative of the brain lesion at all. Especially in the earlier stages of the slowly-growing tumors, tubercles, etc., there may be difficulty in making a diagnosis of brain lesion at all.

Vision

The primary visual area occupies the cuneate and lingual gyri. In the human brain the visual area is placed rather more upon the median aspect than is the case with animals. Because of the partial decussation of the optic tracts, the retinal projection upon the cortex is partially crossed in the human brain. The left occipital lobe receives impulses from the left halves of both retinæ; the right occipital lobe receives impulses from the right halves of both retinæ. The fovea of both retinæ is represented upon both sides of the brain. Thus, the injury of the optic tracts at any point posterior to the chiasma is associated with homolateral hemianopsia, with the loss of the contralateral field of vision and the retention of the field of direct vision of both retinæ. The retina is projected upon the cortex in an inverted manner, so that the lower right half of each retina is projected upon the upper part of the right half of the primary visual cortex, and the lower right half of each retina is projected upon the upper half of the right primary visual area.

The Visual Cortex

The structure of this part of the cortex displays certain peculiarities. The external layer of cells is not particularly well developed. The external layer of large pyramids, found in practically all parts of the cerebral cortex, are here represented by a layer of large stellate cells, among which a few large pyramids, mostly atypical, appear. The internal layer of large pyramids is present, and these pyramids are really giant cells. The seventh layer of polymorphic cells is rather well developed, both in the size of the cells and, in a certain degree, their number.

The association tracts from the primary visual area are

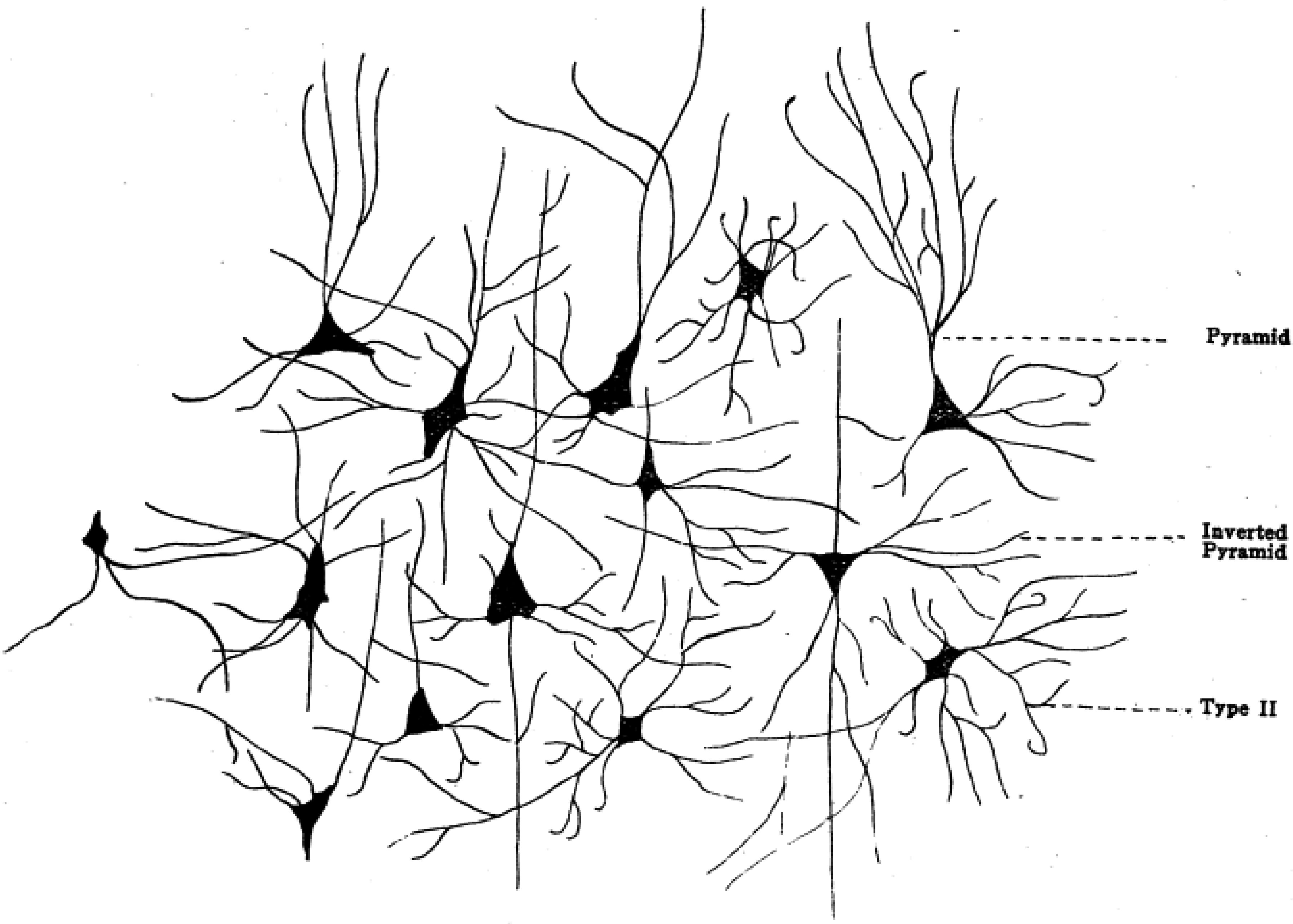

Fig. 8. Cell nest, from human gyrus hippocampus. About 150 diameters. The cells are closely approximated, with very small intercellular spaces. The more freely branching dendrites of the pyramidal cells show similarity to the "tassel" cells of Cajal.

very intricate. This relationship of visual area is indicative of the important place in life which the visual coördinations fulfill.

Color

Whether there is any cortical area for the perception of colors has not yet been demonstrated. The phenomena of color vision present peculiarly baffling problems to the physiologist. The differences between colors, from the physical standpoint, is comparable to the differences between musical tones; that is, it should be perfectly proper to speak of blue as a "higher" or a "faster" shade of red, or of yellow as a "lower" or a "slower" shade of violet. Such ideas are primarily absurd in consciousness, in which these colors are recognized as qualitatively different. The nerve impulses carried by the optic tracts and the resulting activities of the cortical neurons must be identical. How qualitative differences can be based upon quantitative variations in vibration rate is most puzzling.

Origin of Visual Impulses

Visual impulses originate in the retina. The structures of the eye are complex, and may be functional in causing considerable variations in the nature of the impulses sent from the retina and from the essential qualities of the objects seen; in other words, while the peripheral sense organs are supposed to translate environmental qualitative and quantitative variations into the language of nerve impulses, the eye seems to use considerable latitude in the translation, so that a very "free" and idiomatic translation may be made. Thus we have sent to the cortical areas the impulses concerned in the consciousness of qualitative color senses based upon the quantitative variations in vibration rate, that puzzling problem to which reference has already been made.

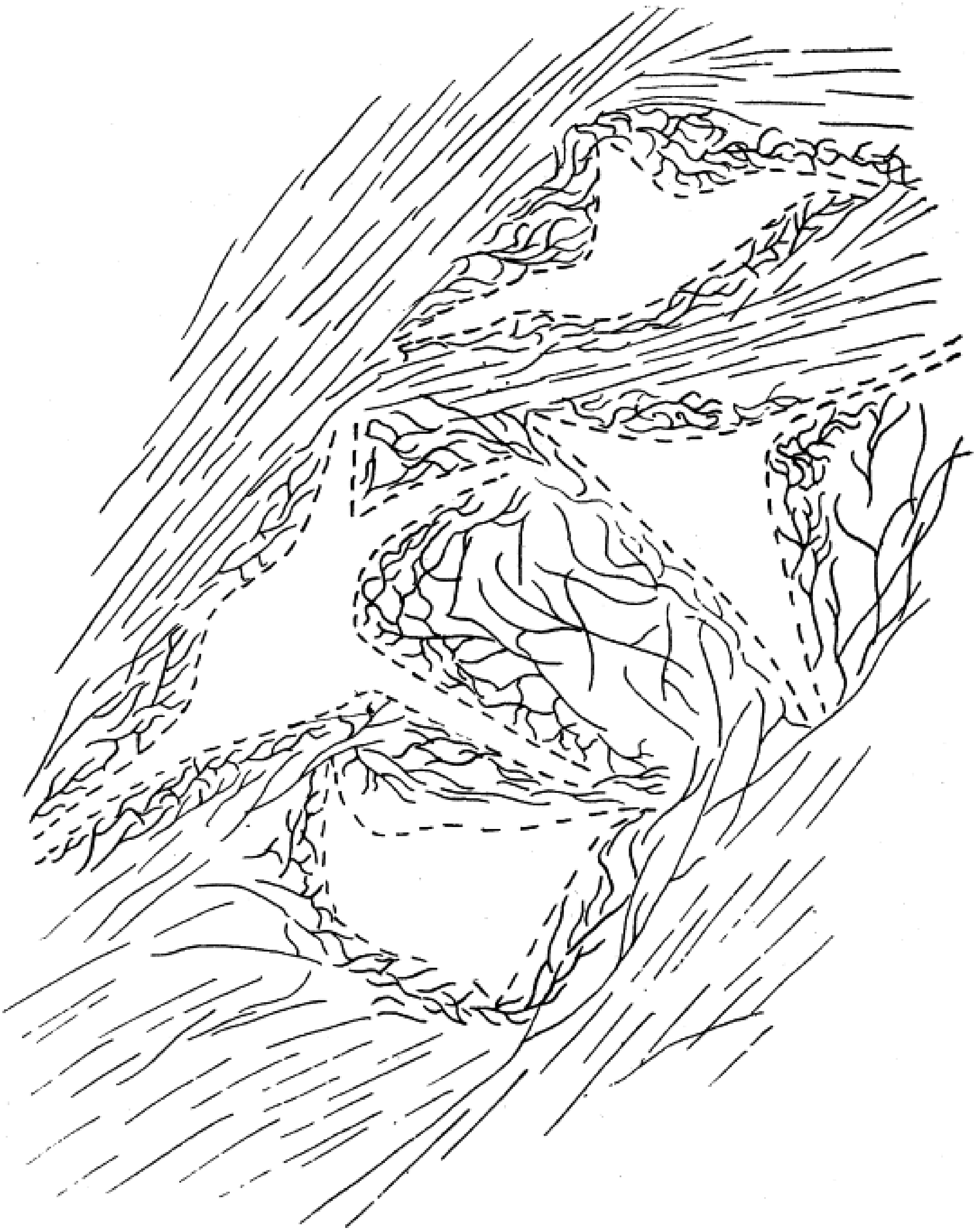

Fig. 9. Terminations of the olfactory tract fibers in the ala cineraea. Adult human brain. About 940 diameters. The cells of the ala cineraea are indicated by the dotted lines; the fibers branching around them are from the olfactory tract.

Physiology of Visual Impulses

Primarily, vision is of a flat, plane surface. The ideas of distance, form, size, space in three directions, and the other ideas ordinarily supposed to be primarily derived by means of visual impulses, arise as the result of the activity of the overflow and intermediate areas.

Cheselden Case

The Cheselden case was reported in 1727. A child born blind was couched when he was between thirteen and fourteen years of age. When the bandages were removed from his eyes he thought things seen touched his eyes. He saw only plane, colored surfaces. Later, having forgotten the name of a certain animal, he picked it up and said, "Puss, so I shall know you next time." The visual impulses seemed not to be associated at first with any ideas of solid form, or of the names of things. Evidently the process of relating the activities of the visual areas to other areas is a matter of a certain length of time.

Other Cases

A man, having been couched, began to see for the first time. He experienced great difficulty at first in learning to eat. For some time he found it difficult to restrain the fear associated with the sight of an approaching fork or spoon toward his face as he fed himself. Another patient, under the same circumstances, displayed the most active delight in the colors first seen. Red, especially, filled him with a sort of joy. He saw red roses upon a bush in the yard. He did not, of course, recognize them, but he did so greatly admire their color that he was with difficulty restrained from climbing out of the window in order to examine them more closely. His incomplete coördinations failed to warn him of

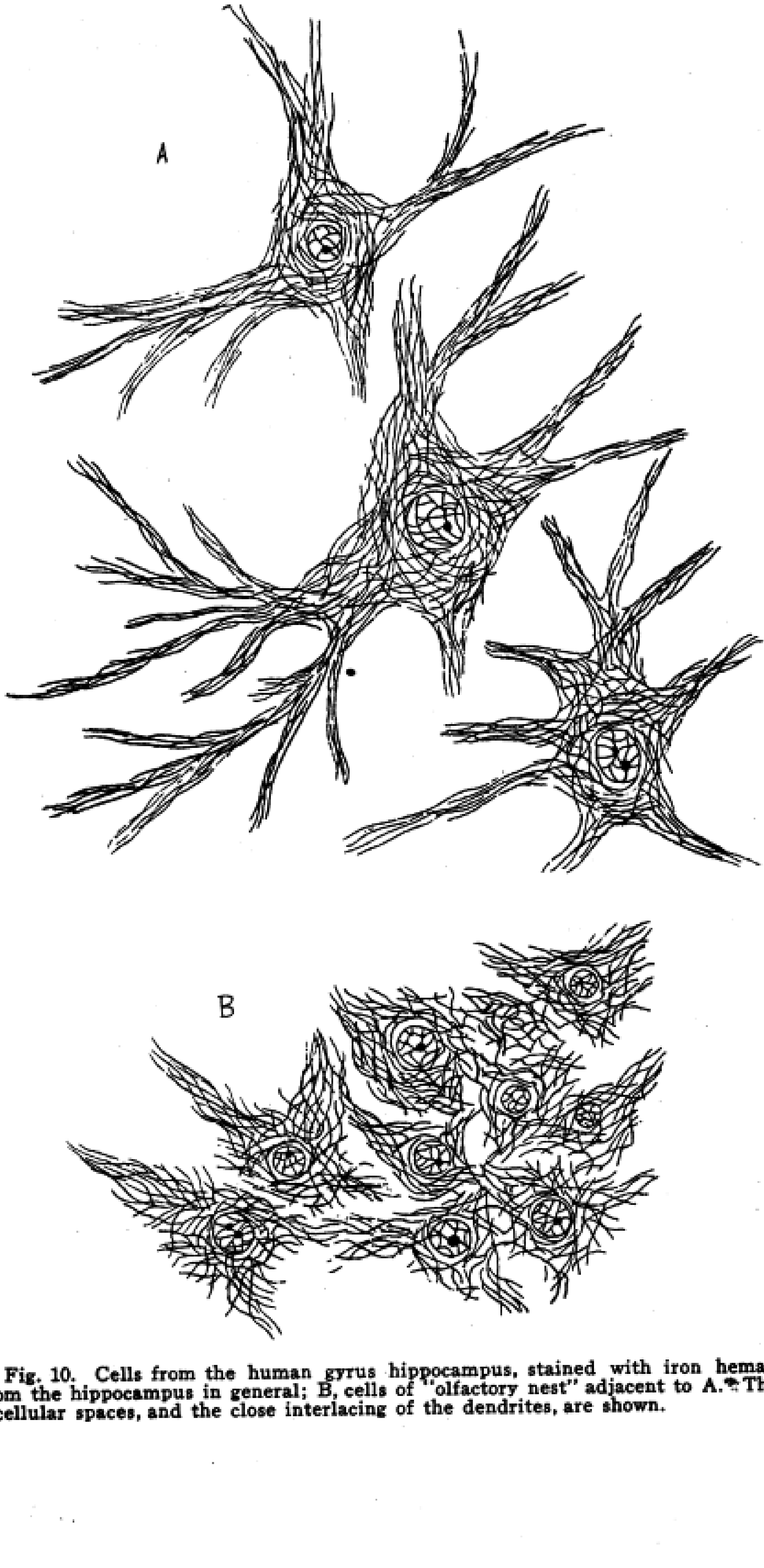

Fig. 10. Cells from the human gyrus hippocampus, stained with iron hematoxylin. A, from the hippocampus in general; B, cells of "olfactory nest" adjacent to A. The small intracellular spaces, and the close interlacing of the dendrites, are shown.

the danger of climbing from a second-story window into a rosebush.

Such instances illustrate the fact that primarily a colored surface only is seen, and that the complex knowledge we think ourselves to receive by sight is, in fact, the result of the primary visual sensations qualified and modified by the activities of the cells of other areas of the cortex.

The Visual Overflow

The visual overflow surrounds the primary visual area completely. Thus, the visual overflow is as extensive in comparison with the primary visual area as it possibly could be. It neighbors the auditory overflow toward the inferior part of its extent, and the somesthetic toward its superior extent.

The structure of the visual overflow presents a type intermediate between the structure of the primary visual area and that of the typical cortex. The stratum zonale is very well developed and is very rich in cell structure. The association fibers are plentiful. The line of Bailarger is unusually well developed, both in the primary and the overflow of the visual cortex. The great development of the fiber tracts of this line is indicative of the great number and complexity of the relationships of the visual impulses.

The cells of this area seem to be concerned in the storing and reproduction of the visual memories. The stimulation of the primary visual area by impulses of a sufficiently energetic or efficient character causes the activity of cells of the neighboring overflow. The activity of these cells, which probably include the cells of the stratum zonale, affects their metabolism in such a manner as to lower their liminal value. This decrease of liminal value appears to be permanent. Thus, the reception of impulses from either the primary visual area or from other cortical centers initiates their activity again. The initiation of the activity of the neurons of the visual overflow

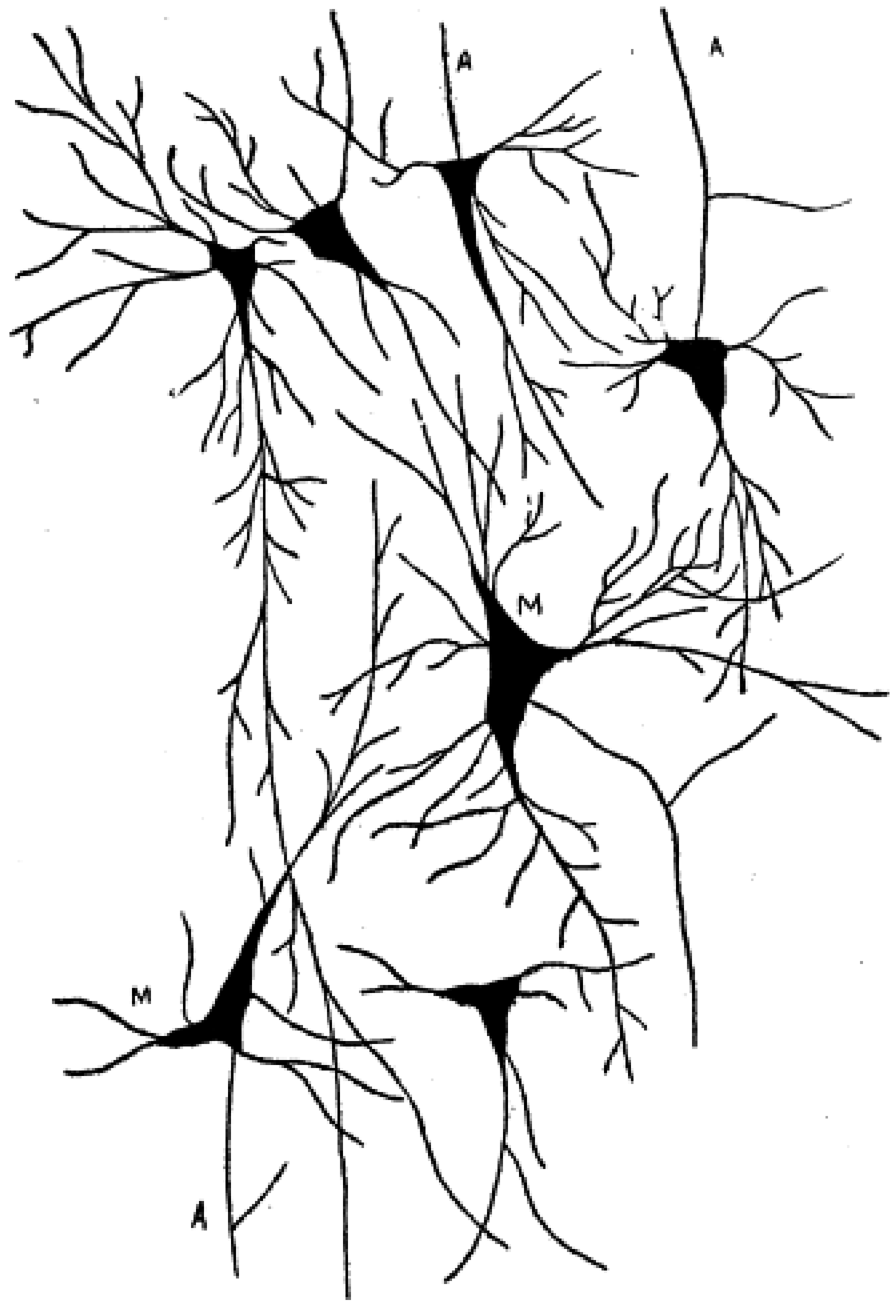

Fig. 11. Cells from human temporal lobe, about 200 diameters. A, axons; M, inverted pyramids of Martinotti.

areas by impulses from the primary visual area is the origin of the visual memories; the stimulation of the cells of the visual overflow area by impulses from other overflow or intermediate areas causes the phenomenon of visual memories in consciousness.

The activities of the visual overflow areas are concerned in the recognition of visual impulses as they are repeated. Together with the areas intermediate between the visual overflow and the auditory and somatic overflows, the ideas of solidity, distance, extension in three directions and various other complex ideas are able to be interpreted in consciousness. These are discussed more fully in connection with the somesthetic and the language areas.

The primary and overflow visual areas give origin to a number of tracts which relate the functions of vision and of visual memories to practically all of the other parts of the cerebral cortex, both of the same and the opposite sides. The very great importance of visual images in intellectual development is thus apparent in the structure of the hemispheres.

Intellectual Functions

The environment is extended to the limits of vision. This, alone, has great importance from the biological standpoint. Animals are able to find food, and to protect themselves from danger much more efficiently on account of the visual impulses.

By means of the visual overflow and the intermediate areas the limits of the environment are indefinitely extended. The activity of the intermediate areas, together with the effective motor impulses, for example, invents lenses and other instruments, by means of which the environment of civilized man is extended to the limits of telescopic vision on one hand, and of microscopic vision on the other. By means of the intricate and efficient fiber tracts of the cerebral hemispheres the impulses derived from this infinite environment add to the wisdom and energy of living in a sense almost beyond conception.

Therapeutic Uses

Visual impulses may be employed very efficiently both in education and in therapeutics. Facts may be stated through the intermediation of sight in a manner which affects the activities of the intermediate and motor areas speedily and energetically. The cartoon as an educational factor owes its value to the fact that it presents its lesson in a simple, concrete form, which stimulates the overflow and intermediate areas much as they are stimulated by the presence of the objects pictured. The moving picture is extremely efficient in a similar manner. Great harm may be done by uncensored motion pictures.

The more highly developed the visual cortex is, and the lower is the liminal value of the neuron systems which relate the visual cortex to the other areas of the brain, the greater are the numbers of associations which are concerned with the activities of the intermediate areas and the resultant activities of the motor areas. These activities are the basis for reason and judgment; hence, the more complex the visual relationships, the wiser the judgments and the more efficient the motor reactions of the individual.

In dealing with patients who are, for nervous reasons, not so obedient as they ought to be, it is often possible to secure more exact compliance with instructions if they are written. In dealing with certain neurasthenic and hysterical patients it is sometimes a good thing to give them "written orders." These are merely instructions concerning food, exercise, bathing, etc., written upon paper and sealed in an envelope. Upon the outside of the envelope is written the hour at which the "prescription" is to be taken. Such methods are efficient in certain cases. It is not usually worth while to try to appeal to the "good sense" of hysterical or neurasthenic patients who are not obedient to instructions. If they had any common sense they would either obey the physician's instructions or go to some person whom they could better trust. But the use of such methods of giving instructions in a manner which impels obedience and adds the interest of curiosity is often a very good thing to do. The method is especially adapted to children, and to adults of slightly deficient development.

Auditory Impulses

The primary cortical auditory area occupies the central part of the first temporal convolution, and probably the upper part of the second convolution. (Figs. 11, 12.) The auditory overflow extends posteriorly to meet the visual overflow of the occipital lobe, inferiorly to an extent not yet defined, and anteriorly and slightly inferiorly into an area which is concerned in the consciousness of musical tones. Neighboring the area for the consciousness of musical tones lies another related area, which may be called the musical overflow. In this area the memories of tunes probably are stored and coördinated. No uncomplicated lesions are described for the area concerned in the consciousness of musical tones or the memories of tunes, but lesions involving these areas seem to affect the power of appreciating tones and tunes. Persons so affected become "tone deaf," and this condition may occur without any loss of hearing as a primary sensation.

It is in harmony with the facts of physiological action elsewhere in the nervous system if it should be found that people who "have no ear for music" have the neurons of this area either undeveloped or of faulty structure. The study of the brains of musicians is also needed in order that such relationships may be determined.

Musical Tones

The areas for the appreciation of musical tones extend toward the olfactory areas. No associations are recognized between these senses, as is the case between the visual overflow and the auditory overflow, or between the visual overflow and the sensory overflow, but both are intimately associated with the lower centers. The appreciation of noises does not affect the emotional centers or the affective states, but musical tones are very efficient in arousing emotional reactions. For this reason music is employed as it is in social affairs, in churches, and under all conditions in which it is desired to bring feelings into play.

No direct association path exists between the anterior temporal area, the musical area, and the motor areas. The consciousness of musical tones, the memories of tunes and the appreciation of the significance of music arouse no marked motor reactions, but appear, on the other hand, to inhibit whatever motor reactions might be aroused by the activity of other cortical areas. It is recognized that music exerts a restful influence upon the body, that it is preëminently adapted to the quieting of those who are inclined to listen with pleasure to it. The physiological basis of this fact is to be found in the absence of direct paths for the transmission of the impulses from the centers for musical tones and memories to the motor areas.

Origin of Auditory Impulses

The auditory impulses originate in the cochlea. The various structures which transmit the vibrations to the fibrillæ of the dendrites of the auditory neurons of the first order appear to modify the amplitude and perhaps the force of the vibrations, but not to modify the essential qualities of vibrations; that is, the vibrations remain as such, and no structure appears to have for its function the translating of vibrations into any other sort of reaction quality, as is the case with certain other sensations. Sound waves are recognized as sound waves in physics, and the physical phenomena of sound coincide with the auditory sensations in consciousness sufficiently for us to realize the relationship between sounds as heard and sounds as subject to the laws governing the vibrations which produce sounds.

The cells of the cochlea send axons as acustic nerves to the acustic nuclei; these in turn send axons to the nuclei of the trapezoid body and the superior olive, the inferior quadrigeminates and the internal geniculate body. The axons of the acustic radiations transfer the impulses thus carried to the first and perhaps the second temporal convolutions. It is not known whether the impulses are transferred by means of all of the nuclei mentioned or not. There is reason to believe that at least a part of the lateral fillet fibers pass without relay from the acustic nuclei of insertion to the internal geniculate body. There is no reason to suppose that the medial fillet fibers, or at any rate more than a very few fillet fibers, pass into the acustic radiations directly.

The Auditory Cortex

The auditory cortex differs slightly from that of other cortical areas. Perhaps the most conspicuous difference is found in the length of the radiations. These fibers extend into the external layer of cells, instead of stopping in the neighborhood of the line of Bailarger. The stratum zonale is rather less pronounced in the primary auditory areas than in the auditory overflow. This structure resembles that of the visual cortex and visual overflow.

The pyramids of the auditory area are not so large as those of the motor area, nor as those of the internal layer of large pyramids of the visual area. The external layer of large pyramids is well represented; the pyramids are not so typical in outline as those of the motor area, but the stellate cells of the corresponding layer of the visual area are not found.

The length of the radiations, permitting the impulses to be carried without relay to the cells of the stratum zonale, is the basis for the fact that consciousness is so quickly affected by auditory stimuli. It is a matter of common experience that a noise arouses attention much more quickly than do other sensory stimulations. A flash of light or an odor fail to attract the attention in so great a degree as do sounds, and even when such stimuli are pronounced enough to arouse forced attention, the reaction is less rapid than in the case of the sounds.

The same condition exists in the area for the appreciation of musical tones. The enjoyment of music seems to be more directly primary in its nature than is the enjoyment of the activities of other sensations, except those of the body itself. Doubtless this depends in part upon the length of the radiating fibers.

The primary auditory areas and the auditory overflow which lies posterior to the primary area are closely associated with the motor areas by the long tracts. Incoming auditory impulses affect the motor areas quickly, as is evident in the phenomenon of attention and in the relationships underlying the speech functions.

The locality where the visual overflow meets the auditory overflow is concerned in the speech mechanism. Injury of this area may be so limited as to interfere with the relationships of the auditory speech area and the visual speech area without affecting in any very serious manner the activities of either center acting alone or in connection with the motor speech area. In such cases the power to read aloud is lost, and the power to write from dictation. But the patient is able to copy from the printed page into writing, or to repeat aloud the sentences spoken to him.

Intellectual Functions

The biological value of the auditory impulses lies chiefly in the facts, first, that the auditory radiations reach the stratum zonale, and thus are able to arouse consciousness and motor reactions very speedily, and, second, in the fact that the environment of the individual is so greatly increased by the auditory impulses. The overflow areas are less extensive than they are in the case of the visual cortex, and the association tracts from the temporal lobes to other parts of the brain are less complicated and widespread than in the case of the visual cortex; yet the auditory area and its connections are of considerable importance from a biological standpoint, as well as from the standpoint of their relationships in the control of human life. The development of the auditory cortex depends upon the stimulation of the cortical neurons by impulses from the lower centers. The stimulation of the primary auditory area affects the cells of the auditory overflow, including the cortical areas for musical tones. The activities of the cells of the overflow area are associated with memories of sounds and with the simpler coördinations of the significance of things heard.

The activities of the cells of the overflow areas are associated, in turn, with increased activity of the cells of the adjacent intermediate areas. These are functional in the coördination of the impulses initiated by the overflow activities, and are associated in consciousness with the correlation of the memories and the abstract ideas built upon the auditory memories and the significances of things heard.

CHAPTER IX

CEREBRAL LOCALIZATIONS, SENSORY.
(CONTINUED).

Smell and Taste

The special senses of smell and taste are widely represented upon the cortex, but the limits of the areas are not known. The two senses seem to occupy practically identical areas, yet the difficulties in the way of exact localization are so great that this matter can not be regarded as settled by any means.

The anterior part of the gyrus hippocampi and the gyrus cinguli and most of the uncinate gyrus seem to be concerned in the senses of taste and smell. Other parts of the rhinencephalon appear to be more efficient in initiating reflex actions than in arousing sensations in consciousness.

Lesions of the areas named are associated with parageusia and parosmia rather than with anosmia and ageusia, since the great extent of the olfactory cortex renders its complete injury almost impossible without death. In certain cases of epilepsy with auræ of smell or of taste lesions have been found in the region of the hippocampus, the uncinate gyrus and the gyrus cinguli. A few cases are recorded in which anosmia has been associated with cerebral lesions. Probably there are individual peculiarities in the cortical areas associated with the consciousness of smell.

No records are found of total ageusia associated with cortical lesions alone.

The Olfactory Paths

The olfactory apparatus is unique in many respects. The olfactory neurons of the first order lie within the mucous membrane. No nerve cells are found upon the surface of the body in any vertebrate, except in the case of the olfactory cells. The fine fibrillæ, which are the dendrites of these nerve cells, are directly affected by the odorous substances. No apparatus is found which has the evident function of modifying in any way the nature of the impulses initiated by odorous substances. Thus it seems possible that at least a certain amount of relationship may exist between the real nature of odors and the olfactory sensations. Yet the odors of substances of similar chemical structure do not necessarily resemble one another.

The olfactory area in the nasal passages is small, even in animals whose sense of smell is acute — the hyperosmatics. In man, hyposmatic, the olfactory region occupies only a few square millimeters. That the impulses originating in such a small area, apparently without any arrangement for increasing or modifying the nature of the impulses thus initiated, should be of so great importance in controlling the activities of the body, and should arouse even as much of consciousness as olfactory impulses do, probably depends upon the wide cortical representation and upon the greatly developed stratum zonale of the olfactory cortex.

The Olfactory Cortex

The olfactory cortex throughout differs from the typical cortical structure. In the uncus and hippocampus the stratum zonale is unusually thick. In the place of the layers of small and medium pyramids are found nests of cells. These nests include two classes, the rather large multipolar cells, with masses of tigroid substance not very closely placed, and the nests of very small pyramids, very closely placed, and which

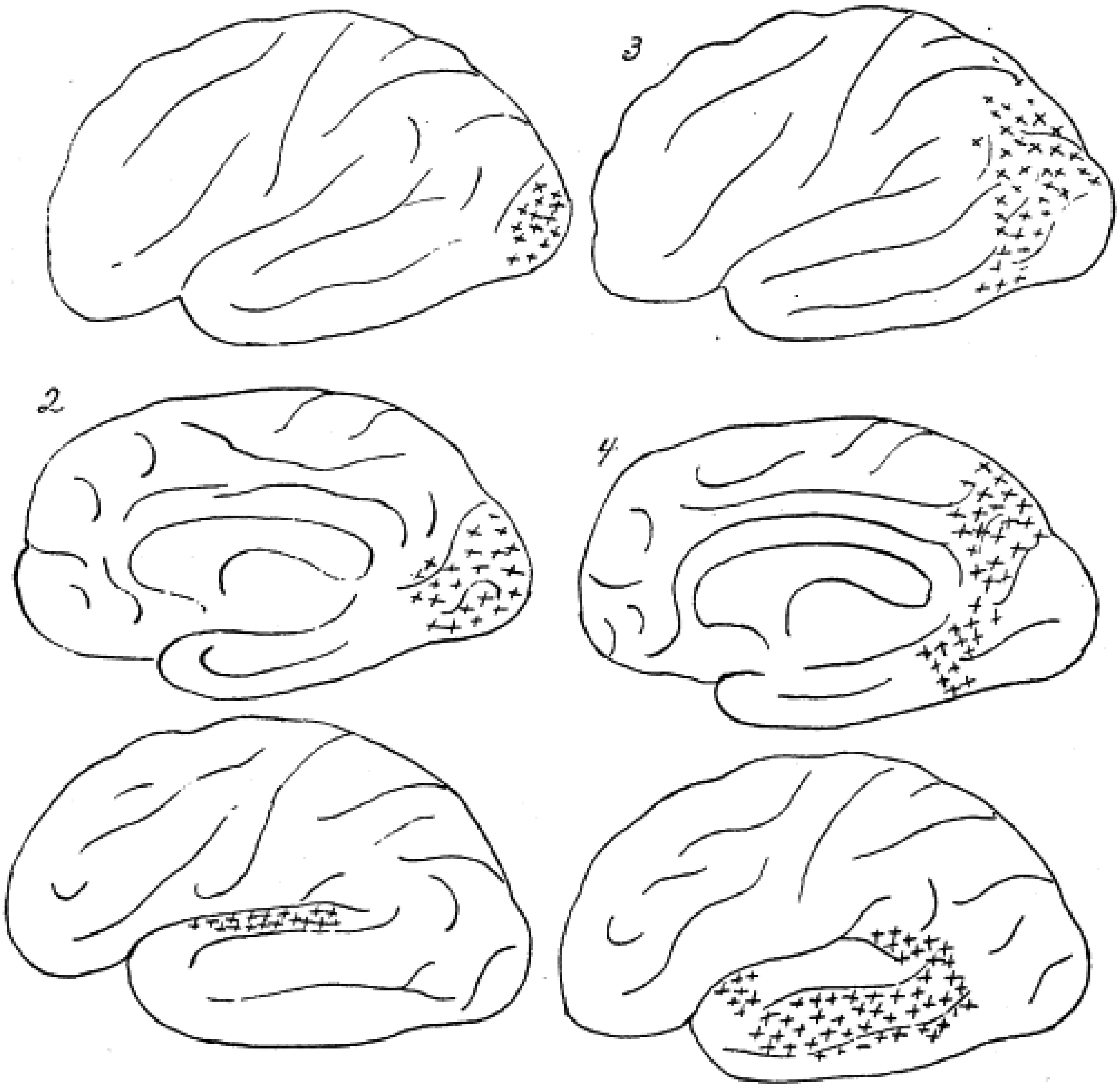

Fig. 12. Diagram of the sensory areas.

1, Lateral aspect of hemisphere, primary visual area.
2, Mesial area of hemisphere, primary visual area.
3, Lateral aspect of hemisphere, visual overflow.
4, Mesial aspect of hemisphere, visual overflow.
5, Primary auditory area.
6, Auditory overflow.

display unusual affinity for the nuclear stains. These nests of cells have very dense pericellular baskets. (Figs. 8, 9, 10.) The large pyramids of this area are replaced by cells of peculiar appearance, which Cajal called "tassel cells." These cells have many apical dendrites somewhat resembling those of the large pyramids, but the basal dendrites trend toward the ventricular surface, and the whole cell assumes a symmetrical appearance, with bundles of dendrites attached like tassels to each extremity of the spindle-shaped body. The axons of these cells seem to pass into the white matter, and probably are carried to other parts of the rhinencephalon. The layers of cells deeper than the tassel cells include the multipolar and fusiform cells, like those found in the typical cortex.

The Subiculum

The subiculum is the lower lip of the hippocampal fissure. Its structure is characterized by the thickness of the stratum zonale and the great length of the radiating fibers, which reach the stratum zonale. The nests of cells are present in the subiculum also. The Golgi Type II cells of the region of the subiculum are characterized by the very great richness of the branches of their axons.

The Gyrus Cinguli

The gyrus cinguli differs from other parts of the olfactory area in having a narrow stratum zonale. The pyramids are small and not to be separated into layers. They are irregular in form and in position. The deeper layers of the gyrus cinguli contain numbers of triangular, polymorphic and spindle cells, which have a most remarkable affinity for stains.

With the exception of the gyrus cinguli, the olfactory cortex is characterized by the nestlike arrangement of the cells, by the great thickness of the stratum zonale, and by the great complexity of association fibers relating the cells to one another. These characteristics are evidently associated with the characteristics of olfactory impulses in consciousness — the appreciation of odors is vague and indefinite; not very much knowledge of things smelled is possible; and the direction from which smells come and the locality of their origin are not to be determined by the olfactory sense at all. Primarily, things are smelled as if merely present. without any ideas of form, distance, locality or origin, and with usually very slight vividness of perception. Only very strong stimulation of the olfactory apparatus is able to initiate vivid consciousness of things smelled in the normal person.

The Rhinencephalon

The olfactory cortex is rather freely associated with other parts of the cortex, but no olfactory overflow area has been found. Thus there is lacking the structural relationships necessary for the development of exact memories and coördinations of olfactory impulses. We have no such exact memories of smells or tastes as we have of the sights, sounds, pain, the temperature sense, sensations of muscular effort, and the other sensations upon which the structure called mentality can be built. Olfactory and gustatory sensations do not form any direct foundation for the processes in the so-called higher intellectual faculties, probably because of this lack of overflow areas. There is not recognized any logical classification of smells; there are no classifications of the objects of the external world according to their odoriferous qualities. We are not able even to classify the primary olfactory sensations in any satisfactory manner. Among normal people odors have very little place in the intellectual life, however much they may affect this indirectly.

Neurasthenics

People whose nervous systems are more irritable than normal, and those who are of the neurasthenic type, with unbalanced nervous systems, are sometimes capable of appreciating smells with quite remarkable vividness. A patient being treated in the clinic of The Pacific College of Osteopathy, a woman of most unstable reactions and decidedly neurasthenic, with a few of the stigmata of degeneracy, displayed very remarkable acuteness in the sense of smell. She was able to recognize the presence of persons of her acquaintance in the next room, and she could tell whether an acquaintance had passed through the room within the hour or two. The very fact of such abnormal acuteness is evidence of atavistic tendencies, and such persons are liable to those defects of the nervous system associated with deficient development. They are neurasthenic or hysterical, under suitable conditions, and are usually more or less unbalanced nervously throughout life.

Olfactory Relations

The intimate relationship of the primitive olfactory cortex to the rest of the cerebrum has never been altogether abrogated. There are found fibers associating the different parts of the rhinencephalon with almost or quite all of the primary and overflow areas of the cortex. As a result of this intimacy of associational relationships the stimulation of the olfactory cortex is very apt to initiate the activity of other cortical areas. This, together with the fact that the olfactory images are not kept in memory (because of the lack of olfactory overflow areas), accounts for the fact that smells are usually efficient for the reproduction in consciousness of visual and auditory and somesthetic images with particular vividness. Somesthetic images may recall visual images, and visual images may recall auditory images, but the presence of odors recalls with peculiar vividness and distinctness of detail the auditory and visual and somesthetic images. The lack of olfactory memories and the fact of the intimacy and complexity of the primary olfactory cortex accounts for these peculiarities.

Olfactory Reflexes

The lack of the importance of olfactory impulses in the more complex and conscious coördinations is not indicative of a lack of importance of olfactory impulses in governing the reactions of life. The olfactory areas are especially intimately related to the ganglionar centers of the cortex. Impulses from the olfactory cortex are carried by way of the fornix and the corpora mammillaria to the thalamic center, and from these to the gray matter around the cerebral aqueduct. From this gray matter the visceral centers of the midbrain, pons, medulla and cord are affected. Thus, the olfactory impulses are efficient in modifying the visceral activities.

From the nucleus habenulæ. impulses are carried by way of the fasciculus retroflexus to the interpeduncular ganglion. and from this center impulses are sent to the somatic centers of the midbrain, pons, medulla and cord. Thus the olfacto-somatic reflexes are controlled.

Functions of Olfactory Impulses

These relationships of the olfactory centers to the ganglionar centers are indicative of the important place of the olfactory impulses in modifying the emotional and instinctive reactions. This relationship is not often recognized. The odors not recognized may yet be efficient as guiding factors during life. The "instinctive distrust" which people sometimes feel for one another is often due to the presence of unrecognized odors. The odor may affect the body so as to produce a slight shrinking due to the activity of certain muscle groups, and a slight visceral disturbance, not recognized as nausea in consciousness; but the sum of the visceral disturbance, plus the muscular reaction, may be sufficient to initiate the unrecognized and "instinctive" feelings of repugnance. These feelings may be pronounced enough to affect the relationships of individuals. On the other hand, similar conditions may account in part for the attraction which one person has for another. Odors have a certain important place, not very often recognized, in modifying the social relations.

Sometimes the choice of one pathway rather than another, the modification of one's position in life, depends upon the antipathies and attractions and repulsions associated with unrecognized odors. These may sometimes govern the reactions which an individual makes to his environment without his really being aware of the fact.

It is in life's pleasures and unpleasantnesses, however, that the most pronounced effects of olfactory impulses are felt. Pleasant odors may cause pleasant memories, and foul odors may initiate such disgust for even beautiful surroundings that the memories may be associated with feelings of dislike for a long time, and thus may affect one's whole future history.

Among the lower animals the sense of smell is of tremendous importance in the sexual life. Among mankind the place of smell during courtship varies inversely to civilization. The passionate delight in odors is probably of a pseudo-sexual nature among neurasthenic or hysterical persons. The odors of certain secretions seem to increase sexual excitement, especially with some persons. Many other people find the odors of the body at all times most repugnant. The more uncivilized races, and the more uncultured among the races ordinarily called civilized, attempt to add to the body odors, and to increase their effectiveness. The attempt to conceal body odors under sweet scents is of later origin, and is superseded among enlightened people by the lack of odor due to exquisite cleanliness and the use of the substances which exhale rather a fragrant freshness than a real perfume.

Even among civilized people there is much difference of taste regarding odors. This is probably due to the fact that the olfactory centers are practically incapable of associative education, that their value in modifying the reactions of the individual is becoming decreased, and also to the fact that the pleasures of odors are more due to the factors associated with the odors than to the primary sensations. For all these reasons the olfactory impulses play a decreasing part in human life.

Through the relations of the olfactory cortex to the lower centers visceral and somatic activity may be initiated. Olfactory stimulation is associated with variations in respiration, pulse rate and blood pressure. The dynamometer shows pronounced variations when the subject inhales certain odors. These variations are extremely variable in different individuals.

Olfactory stimuli seem to increase the tone of certain muscle groups, sometimes apparently without arousing consciousness. This perhaps is the reason why certain individuals find the presence of even pleasant odors associated with great fatigue. The effects of olfactory impulses in lowering the blood pressure increase this sense of fatigue.

It is not possible to make much adequate use of the olfactory impulses in the treatment of disease. An enjoyment of the fragrance of fresh air, of the fragrance of foods suitable to the individual, may be of value in securing better hygienic and dietetic conditions. For the most part, flowers with marked fragrance are out of place in the sick room, unless they are perfectly fresh and the room is extremely well ventilated. Even then flowers of strong odors should not be permitted to remain long in the room.

Gustatory Impulses

The relationships of the taste impulses are equally general. The sense of taste is vivid enough under excessive stimulation, but in ordinary life the taste impulses are not, usually, very vividly present in consciousness. The teachings of Fletcher in this connection are of interest. The digestion of foods which taste well is certainly more complete than is the digestion of foods of equal potential nutritive power which have no taste. This is recognized to be a fact. It follows, then, that the very act of attention to the taste of food should increase its digestion — provided, of course, that the taste is agreeable. Food which is not agreeable to the taste would naturally be omitted from the diet more frequently when the attention is devoted to the taste than when tastes are not consciously perceived. The value of attending to the tastes of foods, then, depends in part upon the increased digestibility of good foods, and in part upon the increased tendency to the omission of foods which are really not fit to eat anyway.

The discussion of tastes in this connection includes the flavors also, which are really classed properly as odors. Since the relationships of the gustatory cortex and the olfactory cortex are probably identical, the separation of the two is of academic rather than of practical interest.

The Common Sensations

Touch and muscular effort are fairly well represented upon the cerebral cortex. The position which these sensations occupy indicates the relations which must exist during the phylogenetic development of the cortical areas. The areas for the sensations of the body in general are located on the post-central gyrus, and the area for the common sensations of any part of the body is placed just posterior to the area in which are located the neuron groups governing the movements of that part of the body. Just posterior and continuous to the area devoted to the common sensations lie the areas concerned in the sensations of the muscular sense. The overflow areas for both these sensations are continuous posteriorly with the overflow of the visual area. The stereognostic centers lie upon the boundary between the two.

The fact that the muscular sense is represented rather farther from the primary motor areas than are the common sensations indicates the later development of the muscular sense as a factor in controlling the motor reactions.

Muscular Co-ordinations

The impulses of muscular effort and of common sensations are of considerable importance in the coördination of the motor impulses. The destruction of the common sensory area or of the tracts transmitting them to the cortex is associated with a certain form of ataxia. In consciousness the bodily sensations are associated with the idea of personality. This is true of the viscero-sensory impulses as well as of those of the common sensations and of muscular effort.

The sensations of touch and of muscular effort add comparatively little to actual knowledge of the environment, acting alone. By means of their effects upon the intermediate areas and through their importance in the coördination of the muscular movements, however, they play a part in the determination of the nature of consciousness which is not to be overestimated. There is present in consciousness constantly a sort of dim and unnoticed background which is made up in great part of the bodily sensations. These are, normally, not vividly appreciated, but under abnormal conditions they may become the most vivid factor in consciousness.

Visceral Sensations

Whether there is any cortical representaion for the visceral sensations, or whether the fibers passing generally from practically all of the sub-cortical centers carry the viscero-sensory impulses, can not now be determined. It is possible that there is no cortical representation of the viscera. This would account, in part, for the fact that visceral disturbances are interpreted in consciousness as disturbances of somatic sensations. Head's Law is concerned here — that the areas of low sensibility are projected in consciousness upon areas of high sensibility innervated from the same spinal segment. This is not exactly true, in all cases. But it is true that, in the cases in which Head's Law seems to fail, a consideration of the cortical, or medullary, or midbrain relations shows that there is a central connection, either spinal or cerebral.

The fact that lesions of the cortex are rarely associated with visceral pain indicates that probably there is not any exact visceral representation in the cortical areas. There is some reason to believe that the vagus impulses are carried to the pre-frontal cortex.

The somesthetic overflow areas are not concerned in what is commonly known as intellectual attainments. But they are indirectly concerned in intellectual processes, since the coördination of those impulses which add value and efficiency to the auditory and visual overflows, which are considered of more intellectual worth, occurs in the somesthetic overflow. The interpretation of visual and auditory images is secured in great part by the coördinations occurring in the somesthetic and motor overflows.

Temperature Sense

The temperature sense seems to be associated upon the cortex with the sensations of touch. A few clinical records are found of persons in whom disturbances of the temperature sense preceded the disturbances of the sense of touch in sensory paralysis of cortical origin. It is not recorded in the papers and books consulted in the preparation of this volume that disturbances of the sense of touch have preceded disturbances of the temperature sense in the purely cortical lesions. It is supposed by certain neurologists that the temperature senses are represented in the cortex by the cells of the outer layers, for this reason. The evidence is rather insufficient as a foundation for such conclusions.

The temperature sense is of value chiefly for the avoidance of danger. The effects produced in consciousness by temperature changes are rather more vivid than in the case with other common sensations. The sense of heat or of cold is largely due to the consciousness of the manner in which the body is reacting to the temperature changes than to a direct effect of temperature changes. The consciousness of the chill, for example, is due to the shivering, the erection of the pilo-motor muscles and the constriction of the peripheral vessels, rather than to the actual temperature of the body, which is usually above the normal at that time. The temperature senses seem to vary. The temperature changes within the body itself may be interpreted in consciousness truly, but very often the temperature of the body itself is either unrecognized at all or is associated with sensations of different character. The sense of chilliness in the beginning of fever, the sense of heat in shock, are instances of this inversion of the temperature sensations. The temperature of the skin is associated with more exact knowledge in consciousness, though this is far from being an exact sensation. The physiological relationships of the various heat areas and cold areas of the skin are yet to be determined.

Sense of Equilibrium

The impulses arising from the vestibular neurons are of a certain importance. These impulses are carried by the sensory neurons of the first order, whose cell bodies lie within the vestibular or Scarpa's ganglion. The axons of these cells pass with the acustic part of the auditory nerve, and are called the vestibular part of that nerve. These axons terminate in the nuclei of insertion of the vestibular nerve. These include several masses of gray matter in the floor of the fourth ventricle, which have not been exactly described. It is known that a number of these cell groups are related to the vestibular nerves. The axons of these vestibular nuclei are sent to the spinal centers, to the cerebellum, and to the olivary bodies, chiefly.

Functions of Vestibular Impulses

These relationships are functional in controlling the movements of the skeletal muscles in accordance with the impulses arising from the vestibular structures. These paths are of importance biologically in the fishes and birds, which are compelled to coördinate their movements with such great delicacy in order to maintain their equilibrium in a medium of about the same specific gravity as their own bodies. In man and in those animals which walk upon the surface of the earth, or which swim upon the surface of water, such delicate coördinations are not needed, and the tract is thus of lessened biological value in these classes of vertebrates.

Impulses from the vestibular nuclei may be carried by the lateral fillet, but it seems more probable that they are carried by the medial fillet, or that the fibers join the spino-thalamic tract as it passes through the pons on its way to the lateral nucleus of the thalamus. At any rate, the impulses finally seem to reach the cortex in the neighborhood of the areas concerned in the body sensations for the head and face.

The impulses carried by the vestibular nerves are efficient in modifying the muscular reactions of the body, chiefly by way of the reflex paths already mentioned, and also by the activity of the cortical motor area. The place of these impulses in controlling motor reactions is noted in Meniere's disease, in which the injury or disease of the vestibule causes a loss or an abnormal condition of the vestibular nerves. The lack of coördination of the muscles of the body is very evident in this disease. The sensations produced in consciousness by Meniere's disease include the symptoms of the disease apart from its neurological aspect, and also a sense of the lack of reality of things present in consciousness, or remembered as having been present in the past. Lesions of the cortex producing similar symptoms are described for the stereognostic area of the left hemisphere, and also for the same area upon the right hemisphere. Lesions affecting the pressure conditions of the brain as a whole also are associated with similar symptoms.

The place of the vestibular impulses in consciousness is very small. It is possible that in part the ideas of the position of the body and the head may be associated with impulses from the vestibule, but this part must be of comparatively little importance. The lack of the normal impulses from the skin, joint surfaces or muscles interferes with the position-sense much more seriously than does the occurrence of Meniere's disease. These clinical considerations seem to indicate that the vestibular impulses give very little consciousness of position. The vestibular sensations appear to be homologous with the sensations received from the lateral line organs in fishes, and the central connections of the vestibular centers are similar to those of the nuclei of the lateral line sensory nerves in those lower vertebrates. The lateral line organs were well on the road to extinction before the cortex had attained any marked functional development. Thus the projection of the vestibular and the lateral line impulses upon the cerebral cortex never assumed any particular importance. The vestibular nuclei retain their primitive relationships with the cerebellum, and are still efficient in modifying the movements of the muscles of the body.

The effects of the vestibular impulses in modifying reactions may be found illustrated in the manner in which people place themselves on a moving car or train. Even in the darkness there is a tendency for people to try to place themselves so that the motion of the stopping and starting of the car may affect the body symmetrically. While it may not be consciously uncomfortable, yet the reflexes aroused by the unequal stimulation of the vestibular nerve endings produces the series of movements which place the body symmetrically in regard to the direction of movement.

The nuclei of the vestibular nerves are closely associated with the nucleus of insertion of the vagus. The sensory impulses from the two nerves, different in distribution as they are, are not readily interpreted in consciousness, and they are not localized. The sensations, such as they are, usually include rather a sense of dizziness and discomfort, rather than a sense of real pain. The impulses carried by the vagus give the same sensations in consciousness. Under abnormal conditions these sensations may be extremely uncomfortable. It is thus not rare that the early stages of Meniere's disease may be mistaken for some digestive disorder.

The place of the vestibular nerve impulses, like the functions of the other viscero-sensory nerves of the body, must be found in their action upon the lower centers. The impulses carried by these nerves, the vagus and the vestibular, should not be permitted to affect consciousness in any degree avoidable. The sense of pain and discomfort should arouse the reactions which tend to the relief of the pain, but after the sensation of pain has initiated the appropriate motor reaction, the only thing to do is to inhibit the further stimulation of the neurons concerned in carrying the impulses of discomfort. This is done most efficiently by causing the increased activity of other neuron groups, not concerned in the appreciation of discomfort. In planning this increased activity, it must be remembered that the neurons of the cortex, whose activity is essential to conscious phenomena, are governed by physiological laws, and that their increased or modified activities must be based upon the same laws which govern the activities of the spinal centers, or any other neuron groups. Thus it is necessary, in dealing with persons who because of nervous abnormalities feel pain in the absence of efficient causes of pain, to provide, first, those circulatory and nutritive conditions needful to normal neuron activity, then to cause those parts of the cortex which have been left rather undeveloped to be stimulated by streams of normal nerve impulses. This increased stimulation of the cortical areas, not associated with the pain and discomfort, lessens the liminal value of those other neurons; the constant streams of stimulation associated with normal living do not find the excessively irritable areas concerned in pain sensations, and the consciousness of the individual is unaffected, ultimately, by any pain sense not originating from really injured parts of the body.

Stimulation of other cortical areas is easily done in persons of anything like normal nervous systems. Any form of new activity, the recrudescence of any old fad, or the training of unused muscles may be effective in lowering the liminal value of new areas, and in giving the hyper-irritable neurons opportunity for recovery.

CHAPTER X

MOTOR AND INTERMEDIATE AREAS

The intermediate areas are those placed between the different primary and overflow sensory and motor areas. The primary areas are, for the most part, surrounded by the overflows. Between the overflow areas lie the intermediate areas. These have been called indifferent areas, because of the fact that their removal or injury was found to give rise to no localizing symptoms in the cases first studied, and that the experimental stimulation of these areas in the brains of animals and in the brains of a few human beings suffering surgical injuries produced no bodily movements. They have been called association areas, because other facts of clinical evidence indicated that they were in some way concerned in the association of ideas. They have been called unused areas, because no function was at that time ascribed to them.

Partly because of the studies of Flechsig and partly because of many clinical reports the view is now accepted that the cortical areas of the left hemisphere altogether, and probably most of the right hemisphere in human beings, are concerned with important functions. The areas are properly "intermediate" areas, since this term conveys no false psychological ideas. It is not known whether the intermediate areas are any more concerned in consciousness than are other areas, or whether they are to be considered as concerned in consciousness at all. They are placed between the sensory and motor overflow areas, and the term "intermediate" conveys no unbased or indefensible ideas concerning psychic relationships.

MOTOR AND INTERMEDIATE AREAS

The areas intermediate between the overflow of any primary area and the overflow of any other primary area are concerned in the association of the impulses from both overflows.

The Stereognostic Area

In the precuneus, near the mid line, there is an area called the stereognostic center. This occupies the area between the visual overflow and the somesthetic overflow. It will be remembered that the somesthetic overflow includes as part of its functions the retention of memories of simple muscular movements. Thus, the area between the visual and the somesthetic overflows is concerned in the appreciation of ideas resting upon the proper correlation of the primary sensations of sight, touch, and the sensations associated with simple muscular efforts. This is the physiological basis upon which objects are seen as having extension in three directions, as having solidity, of being placed at a distance, and of being real, rather than unreal and evanescent.

Lesions

Lesions of the stereognostic area are associated with sensations due to the lack of these coördinations; there is seen only a flat, colored surface, as the primary visual area produces the sensations in consciousness. No ideas of space in three directions are possible under such conditions. Touch gives ideas only of plane surfaces; muscular effort alone gives ideas only of resistance to effort; hearing gives no idea of extension in space, primarily; and the individuals so injured are able to perceive nothing as solid, thus nothing as real. Things absent from immediate environment are not to be thought of as having existence, though memories of past experiences may be normally vivid. Such memories are like the memories of a very vivid dream, whose elements are vividly present as memories, but whose unreality is not to be questioned.

Area for Equilibrium

At the posterior extremity of the temporal lobe, and extending somewhat into the parietal and the occipital lobes, lies an area with undetermined limits, whose injury results in a lack of conscious equilibrium. The person so injured may not stumble or lose his balance; he may be able to perform rather complex acts with no apparent difficulty, especially if he does not pay any attention to the actions. But he has no sense of proper orientation to his environment; he is afraid of stumbling, and this fear may make him actually fall. But so long as he attends to other things the activity of the lower centers of coördination seem able to govern his movements fairly well. Such a person is apt to lose also the sense of orientation in other directions; he may find himself always with a feeling of being out of place, of being unwelcome, of failing in his efforts to perform his duties satisfactorily, or of having engaged in the wrong vocation. It is probable that an unbalanced functioning of this area may be associated with the peculiar mental make-up of the proverbial "rolling stone." The constant effort to orient the reactions to the environment in a satisfactory manner results in constant changing of vocation and constant change of environment. Sick people of this type go from one doctor to another and try fad after fad of pseudo-hygiene and diet. The religious life may be affected by such deficiencies; the persons thus affected change their denominational affiliations with the changes of the seasons. The remedy for such conditions, when dependent upon unbalanced development, is educational. Children who display such tendencies should be taught to postpone the expression of unrest until the environmental factors have been thoroughly examined. The manner in which these educational factors may be used is discussed in a later chapter of this book.

Anterior Association Area

There are three well-marked intermediate areas. These have been called the anterior, middle and posterior association areas.

The anterior association area occupies those parts of the frontal lobe not occupied with the motor overflow, the writing and speech centers, and the primary motor area. This area presents no marked variations from the typical cortex, except that the line of Bailarger is rather well marked, and the association fibers of Meynert are present in rather large numbers. The sensory impulses from the viscera may be received by this area, though there is much reason to doubt the matter. The motor overflow extends well forward, and probably the activities of the neuron systems of the motor overflow are important factors in the determination of the ideas of personality.

The anterior intermediate area is concerned in the coördinations of those nerve impulses which are concerned with the relationships of the individual to his environment. Lesions of this area are associated with a lack of the normal reactions of the individual to his fellow man, and to the circumstances of his life. He is apt to be foolishly extravagant, foolishly egotistical, and often his lack of consideration for the rights of others or for the commonest ethical considerations cause him to perform criminal acts.

Abnormal Conditions

Lack of normal relationship between this area and other intermediate and overflow areas causes the individual to be peculiar, to assume at times a demeanor of extravagant humility, at others the most arrogant self-conceit. The same contradictory characteristics may be found in the same person, or any individual may display only one set of the characteristics. Normally, the activities of the frontal areas control the activities of the lower centers, and they are concerned in the coördination of the impulses initiated by the activities of all parts of the cortex. It is this area whose activity is concerned in deciding the manner in which the individual shall react to any given environmental change. In other parts of the brain the propriety of the proposed action is decided, but in the anterior intermediate area the reaction which the certain person is to make to the certain stimulation is decided, not always in accord with the decisions made by the posterior areas.

The activity of the neuron systems of this area, as they stimulate the neurons of the motor area to action, causes the phenomenon called volition, or will "power," in consciousness. Impulses are not sent from the anterior intermediate area because of the "power" of the will, but the sense of will power results from the transmission of these impulses, with the associated activity of the giant cells. The larger the cells stimulated, the greater the sense of power in their activity. Thus, if it is desired to cause a sense of well being in the neurasthenic, it is only necessary to cause him to contract the large muscles, those concerned in extending the spine, throwing up the thorax, extending the arms, breathing deeply, etc.

The Insula

The middle association area is that of the insula, or the island of Reil. The nature of the processes coördinated in this area is not known. It was formerly supposed that the insula was concerned in speech, but later studies have shown that not the insula, but the fibers under the insula, carrying impulses from the auditory to the motor speech center, were concerned in speech. It now seems probable that the insula is concerned in the association of abstract ideas.

The Posterior Intermediate Area

The posterior intermediate area occupies part of the parietal lobe, chiefly on the left side of the brain. The common sensory and muscle sense overflow bounds it anteriorly, the auditory speech center bounds it inferiorly, the visual overflow and the visual speech center bound it posteriorly and inferiorly. The stereognostic sense occupies part of the area.

In this area the impulses are coördinated which are concerned in the appreciation of the factors of the environment, without especial regard to the personality. By means of the activities of these neuron groups the abstract ideas are related; the memories are associated together, and with present experiences; objects are classified, scientific attainments become possible, and all of what are ordinarily called higher intellectual attainments are secured. Nevertheless, it must be recognized that the activity of this area is of value only as it modifies the individual's reactions, either for the present or for the future. It may be that this modification is only for the sake of giving his wisdom to others who may use it, but it must be remembered that the unification of the race in attainments is one most important function of the nervous system. It is in the activity of the posterior intermediate area that this function is most completely performed. It is here that those coördinations are secured which add to the sum total of the world's knowledge, which plan future events, which engage in altruistic work, generous deeds, with no thought either of self-seeking or of self-sacrifice. Either sacrifice or selfishness compels the activity of the anterior intermediate area.

The Motor Areas

The gyrus anterior to the central fissure (of Rolando) is concerned in the discharge of the motor impulses which govern the movements of the skeletal muscles, so far as these are under volitional control. The gyrus posterior to the central fissure is concerned in the sensations associated with the same parts of the body. The body is thus projected upon the cortex of the central areas much as the retina is projected upon the occipital cortex. The map of the cortex displays a projection area which is, very roughly, a map of the body, in which the body is inverted and placed somewhat in the embryonic position.

The cortical area represents the contralateral half of the body. The movements of the feet and toes are governed from the area upon the medial aspect of the hemispheres. The movements of the legs and thighs occupy the area upon the upper aspect of the hemispheres; a little lower lies the area in which the movements of the lower part of the body itself are controlled, then the areas governing the upper part of the body, the shoulders, arms, hands, fingers, face and neck appear in order. The movements of the head are probably controlled from an area lower than the finger area, though certain facts of clinical and post-mortem evidence seem to indicate the control of the head movements from an area just lateral to that controlling the hands.

Destruction of the motor area is associated with a loss of the so-called volitional movements, and the muscles controlled by the injured part of this area suffer spastic paralysis.

Experimental stimulation of different parts of this area causes movements of certain muscles, according to the area stimulated. Experimental ablation of different parts of the motor area in animals causes paralysis of certain muscle groups, and these paralyzed muscles are about the same as those found paralyzed in the man or woman who suffers from lesions of corresponding areas. In this connection the results of experimental stimulation, experimental ablation, clinic evidence and post mortem examinations all agree within fairly well-defined limits.

The Motor Cortex

The structure of this area is peculiar because of the extremely large pyramidal cells of the internal layer of large pyramids. The line of Bailarger is not well marked in the motor area. This is, no doubt, due to the fact that the cells act more as units in the emissive part of the cortex than in the receptive areas. The coördination processes are performed in the overflow and intermediate areas, and the impulses resulting from the related activities of those cells cause the stimulation, in the motor area, of the cells essential to the performance of some certain action. Probably there is a certain amount of coördination in the motor centers, but this must be much less than is the case in the overflow and intermediate areas. The lack of the line of Bailarger indicates this lack of correlation of motor impulses in this area.

Motor Overflows

The motor area receives impulses from practically all parts of the cortex. The overflow lies just anterior to the primary motor area. The overflow near the center for any group of muscles may become developed for the performance of especially complex actions of those muscles. The speech center, just anterior to the area for the movements of the tongue, lips, laryngeal muscles, etc., and the writing center, just anterior to the center for the movements of the hands and fingers, illustrate this relationship. Certain facts of clinic evidence seem to indicate the existence of other areas for the performance of movements of considerable complexity. These have not been exactly defined, partly because of the impossibility of animal experimentation in investigating such relationships, and partly because uncomplicated brain lesions associated with the loss of these complex reactions, except in the case of speech and writing, have not been reported.

Nature of Volition

The stimulation of the motor area by impulses from other cortical areas gives rise to the consciousness of effort and the exertion of effort. The tendency in consciousness is to assume a psychological energy-producing volition. The facts of experimental and clinical evidence indicate that this consciousness of volition is the result and not the cause of the stimulation of the efferent neurons of the motor cortex; in other words, the movement occurs, and this produces the consciousness of volition. The occurrence of the movement, however produced, gives the consciousness of increased energy, and this may serve as a means of increasing what is usually called the will power to a noticeable extent. If the sick and feeble person can be stimulated in any way to move the muscles concerned in volitional efforts, the effect in consciousness is about the same as if he chose to perform the same movements in the same way.

Abnormal Conditions

The largest pyramidal cells of the motor area are those concerned in the activity of the largest and most powerful muscles. Stoddard makes use of this relationship in describing the pathology of the manias and the melancholias. He infers the existence of some paralyzing agent formed within the neuron by its own abnormal metabolism. This substance affects the larger cells most profoundly, since these have the greater mass, with metabolic processes which vary according to the cube of similar dimensions, while their eliminative powers are limited by their surfaces, which vary according to the squares of their like dimensions. The weakness of the larger muscles, which hold up the head and shoulders, extend the back, etc., gives the picture of the person suffering from melancholia.

If any poison should be circulating through the blood, however, the smaller pyramids should suffer most profoundly, since their powers of absorption are greater compared to their mass than is the case with the larger cells.

The remarkable restlessness of the smaller muscles, which move the fingers and toes, in persons suffering from various forms of toxemia, illustrates the effects of the extracellular poisons upon the smaller pyramidal cells of the motor cortex. The stimulation of the smaller pyramidal cells of the cortex is associated in consciousness with the feeling of nervous irritability and inefficiency. This is easily determined by experiment. The stimulation of the large pyramidal cells of the cortex is associated in consciousness with a feeling of efficiency and power. This also is easily verified by experiment. If any one has the feeling of inefficiency and a lack of power in any way, if he will contract the larger muscles of the body, those which hold the spine erect, draw the shoulders back and hold the hips and thighs steady, the effect produced in consciousness is that of increased power. On the other hand, if one permits the shoulders to droop, the spine to fall into increased curves, and the hips to become unsteady, the effect produced in consciousness is that of weakness and inefficiency. Contraction of the smaller muscles which move the fingers and toes, however forcible these may be thrown into action, does not give the consciousness of strength that the contraction of the larger muscles, due to the activity of the larger pyramidal cells, gives. This should be one factor to be considered in outlining exercises which are to be employed by the patient in certain spinal curvatures, etc. The patient who is down-hearted and has too vivid a sense of his inefficiencies should have given him those exercises which include the energetic action of the large muscles, while the person who does not suffer from this sense of weakness may have only the exercises absolutely required for the correction of the structural abnormalities.

Therapeutic Principles

In dealing with neurasthenics whose symptoms are of a melancholy type, the use of exercises involving the contractions of the large muscles is of value. The contraction of these muscles may be made of use in giving whatever corrective movements are needed in certain cases. Any movements which the patient is compelled to make under the eye of the physician seem to be especially efficient in modifying the physiological activities. This is, no doubt, because of the increased stimulation due to the presence of some one in authority. The more earnestly the patient endeavors to perform any given action properly, the greater is the stimulus given to the intermediate and overflow areas, and the greater is the educational and therapeutic value of such actions. It is much more important that a patient should try earnestly to perform his exercises properly than it is that he should perform them properly. Thus, the value of having the patient go through the exercises in the presence of the physician or his assistant is evident.

The Motor Overflow

The extent of the motor overflow is not exactly known. Certain clinic histories seem to place it upon the cortex anterior to the primary motor areas, while other cases show evidence of a locality posterior to the area for the common sensations as being concerned in muscular memories. It is possible that both areas may be concerned in the coördination of the muscular memories. The physiological relationships involved are not modified by the structural dissociation of the overflow, even if it should be found to occupy areas not continuous.

Lesions

The symptoms noted in the cases of patients in whom deficiencies of muscular memories were found to be associated with lesions of the parietal areas included rather the loss of ideas associated with external objects and the resistance which these offered to muscular movements, rather than to the movements themselves. The lesions of the parietal area caused the patient to be unable to remember the consistency of objects, their distance, their form as determined by touch, and the relative positions of objects. The stereognostic sense is usually lost or injured in such cases. The lesions of the frontal areas, on the other hand, are associated with the loss of the memories of the movements themselves, without regard to the effects of the movements, or the knowledge gained of external objects. The representation of muscular memories appears to be of at least a twofold nature, and the consciousness as affected by these memories must be of rather a complicated description.

Muscular Memories

The sensations associated with muscular effort are remembered, as other sensory images are. The memories of muscular effort are of considerable biological significance in the maintenance of individual personality. The memories of muscular movements are probably of rather late phylogenetic development, and are found to possess certain qualities characteristic of the consciousness associated with the activities of developing cortical neurons. In the first place, the muscular memories are poorly differentiated from muscular sensations. The very thought of performing an action in any certain manner gives rise, in consciousness, to the sensation of performing that act. Thus it appears that normal people, awaking from sleep, may think honestly that they have arisen and are preparing to do the day's work, though, as a matter of fact, they are only dreaming. Again, children, not recognizing the differences between muscular memories and muscular sensations, are apt to state long, and complex, and impossible stories of their experiences, as if these had actually occurred. These highly imaginative experiences are actual, so far as the child's consciousness goes; the muscular memories are simply dissociated through the incomplete action of the cortical neurons, and the elements are recombined with associated impulses from other cortical areas, and the effects in consciousness are thus practically identical with the effects produced in consciousness by actual occurrences. The children who are punished for "lying" are not more bewildered nor more unfairly treated than are those who are ridiculed for their "precocity." The rational treatment of such children is simply to ignore the sayings to a great extent, and the further development of the overflow areas makes the appreciation of the facts of actual life more vivid in consciousness. Ridicule and punishment fix the whole occurrence more firmly in the memories, and delay the normal development of the neurons concerned in the memories and recognitions of muscular movement and personality.

Personality

The ideas of personality are intimately associated with the memories of muscular activities. The development of the cortical areas associated in consciousness with the muscular memories is associated with the strongest personality ideas. The "weak character" is that of the person in whom the impulses from the primary and overflow and intermediate areas are not associated with motor impulses. Persons of great mental worth, of sound judgments, of high intellectual attainments, and most admirable characteristics otherwise, may yet be inefficient and without much force because of the lack of the development of the cortical areas associated with personality — that is, with the memories of muscular effort.

Educational Principles

In increasing this developmental process it is necessary only to see that the impulses associated with the activities of the different cortical areas are interpreted into terms of movement as quickly and as energetically as possible. It is not at all desirable that the movements be actually performed in many cases. The vivid appreciation of the character of the movements which should be performed is almost or quite as efficient in development of the neurons of the motor overflow areas as is the actual motor reaction.

The actual motor reactions are essential, of course, to the securing of motor memories. Sometimes people have not even the motor memories well developed. Those persons are of very weak and inefficient personality. They must be treated as children are, and their developing efficiency must result from increased use of the motor reactions. They must be encouraged to do things quickly, with the appearance of interest, whether they feel interest or not. They must be taught to decide quickly and to do things quickly, and to stand for their decisions. They must be taught to interpret all sensations and intellectual actions into terms of actual or imagined muscular effort, and they must be taught to try to appreciate vividly the feelings associated with earnest, and energetic, and enthusiastic work, and play, and urgent endeavor.

In trying to secure the development of the stronger personality in those who are deficient in this direction it is not necessary or particularly desirable to arouse any feelings of interest or determination. The essential thing is to see that the impulses concerned in the expression of interest and determination are sent through the cortical areas associated with these psychical factors.

If any person acts as if he were energetic, and interested, and enthusiastic, and if the physiological requirements of nutrition, pressure, etc., of the cortical neurons are met in a fairly adequate manner, the development of enthusiasm and force of character must be a matter of a comparatively short time. The older the person is, and the more seriously his cortical neurons have been injured by faulty use and disuse, the longer the development of the normal activities requires. This development may occur at any time of life. The person who is young enough to recognize a fault in his own mental make-up is young enough to correct that fault. The neurons concerned in the reactions expressive of any personality are those whose activity confers that personality. If any characteristic is desired, it is only necessary to act as if one possessed that characteristic, in its essential sense. The effort required to appear to others to possess any characteristic confers only the qualities associated with imitation, and hypocrisy, and affectation; but the effort required to place every factor of any desired characteristic plainly and vividly in consciousness, both from its sensory and its motor standpoint, confers the essential features of that characteristic upon the individual in as great a degree as the structure of the neurons and their relationships permit.

The same laws govern the undesirable characteristics. If any person or any child is so placed as to be impelled to look upon undesirable traits constantly, even if he sees them with horror and disgust, the neurons concerned in the reactions associated with those traits have the lower liminal value, and his character becomes modified in accordance with the same law. This exception is found: if the person so placed constantly interprets the actions he sees with horror into terms of antagonistic activity, then the antagonistic reactions may become the more pronounced. But the vivid appreciation of horror and disgust with no associated motor images of antagonistic nature are of no avail in preventing the undesirable factors of environment from affecting adversely the character of individuals who perceive them. It is said that the persons of weak personality are not able to do good work in the slums, among the wicked, and so on, while persons of strong personality are not so apt to become wicked themselves if they try to engage in missionary work. The essential difference is simply this, that the person of what is ordinarily called weak personality is the one whose motor areas and motor images are associated with the activities of the sensory areas rather than with the activities of the overflow and intermediate areas. The relationships may be very intimate between the primary sensory areas and the motor areas, in which case any person is apt to react according to every change in his environment, "tossed about by every wind of doctrine." Such a person is apt to be unendurably obstinate, holding with relentless obstinacy the edicts based upon the appreciation of comparatively few environmental factors, or he may vary with the weather vane, or he may display alternate obstinacy and variability in a manner which puts him at the mercy of any person who is shrewd enough to take these characteristics into account, and shuts him out from the common sources of knowledge as found in the fellowships of every-day life. The daily variations of obstinacy and pliability depend in such persons upon the variations in the physiological conditions of the neuron systems concerned in the relationships of the motor areas, the sensory and intermediate areas, and the different ganglionar centers in which the instinctive and emotional reactions are coördinated.

In dealing with patients who possess this peculiarity of mentality, it is necessary to manage them at first in accordance with that peculiarity. It is often necessary to take advantage of every whimsy in order to secure the obedience to hygienic procedures and the coöperation necessary in making the structural corrections which are essential to recovery. The aim should be to appeal to the logical faculties and the common sense of the patient whenever possible; but if he has no common sense and his logic is one-sided, if he has nothing perceptible but an accumulation of whimsies and habits, then those whimsies must serve as a basis for the development of new habits and a saner mentality. Again, it must be remembered that the development of the neurons concerned in any reaction makes that reaction the more liable to recur under similar conditions. If the patient can be induced to act as a reasonable and obedient being in a few simple matters, he may gradually be taught to care for his body and to coöperate with the physician in a comparatively sensible manner. As the rational physician works to secure better circulation, better structural relations of the different parts of the body, the conditions needful for the maintenance of proper nutritive conditions for every part of the body, as he explains these things in a manner suitable to the understanding of the patient, the educational factors are being met with the greatest wisdom. The very fact that the patient yields even the faint obedience of turning over upon the treating table is a foundation for the educational factor needed in these cases.

The Fetal Position

The position which the body assumes under the effects of certain physiological and pathological conditions of the cortical neurons is of interest in this connection.

The tendency to assume the fetal position under stress of the depressing emotions is well known. This position is that which places the least tension upon the larger veins of the body, and thus it decreases the rapidity with which the blood reaches the right ventricle of the heart. The amount of blood flowing to the lungs is thus decreased, the rapidity of the heart's action is lessened, and the arterial pressure is decreased. This is associated with the lack of the normal oxygenation of the blood and thus of the tissues, including those of the nervous system. It is not now evident whether any beneficent reaction can be associated with this series of events, which at first view appear to be rather malevolent, so far as the physiological effects are concerned. The effects produced in consciousness by these physiological occurrences are those associated with inefficient activities of the cortical neurons in general, namely, a feeling of weakness and inefficiency and the persistence of the images associated with depressing and unpleasant circumstances.

The fetal position must be that associated with the most efficient growth, else it would have become lost in the process of phylogenetic development. The conditions associated with most efficient growth are those most suitable for the repair of injured or diseased tissues. It would seem probable that in some way this position is associated with repair, and that, while the series of events as they occur under depressing emotions seem to be rather malevolent than otherwise, it may be that the ultimate tendency is to the relief of the high tension, the rest of the neuron systems concerned, the elimination of the products of metabolism, and the ultimate recovery from the condition of excessive emotional depression.

The fetal position is that which is employed among many of the prehistoric races in burial, as well as among many savages of this day. Some of the very earliest remains of the paleolithic man show this position. The very earliest of the Egyptian remains show the same position. All over the world the evidence is fairly conclusive that the placing of the dead in the fetal position is constant. Among certain races this position is assumed in sickness, and especially when death is imminent.

The position produces the sense of a lack of tension and of inefficiency. The lowering of blood pressure under the influence of the position is often considerable. Under certain abnormal conditions, as in apoplexy, and when for any reason the lowering of the arterial pressure is indicated, the position is often naturally and involuntarily assumed, and is beneficial. If it is not assumed involuntarily, the body may be placed in a similar position, in order that the arterial pressure may be lessened in that manner unless some other factors of the case interfere with the propriety of the assumption of such positions.

In certain of the East Indian philosphies the attainment of wisdom and merit is facilitated by the assumption of almost the fetal position. The result of the lessened tension upon the larger veins causes lowered arterial blood pressure. Deficient oxygenation of the blood occurs as the result partly of the decreased amount of blood reaching the lungs and partly as a result of the impeded respiratory movements produced by that position. The lack of the efficiency of the intermediate and motor areas is noticed first, because of the higher development of the neurons of these areas. The ganglionar and lower centers thus remain in unimpeded activity. The consciousness associated with the relaxed muscles, the lowered blood pressure, the inactivity of the whole body in the lack of sufficient oxygen and the lowered blood pressure, together with the lack of activity of the motor and intermediate areas, is that of a dreamy, contented, unemotional, unvolitional, impersonal happiness, or Nirvana. The higher development and the lowered liminal value of the cortical neuron systems of the Occidental brain makes the attainment of this state among normal Americans or Europeans almost impossible.

Development of Strength

The relationship between the contraction of the larger muscles and the associated activity of the larger pyramidal cells and the conscious phenomena of strength has been discussed. The constant use of the larger muscle groups is associated with the development of the larger pyramids, and with the increased activity of the neuron groups concerned in the feelings of strength and efficiency. Thus, it is evident the person who needs "bolstering up" should be compelled to employ those larger muscles constantly. The larger muscles are those of the shoulder and pelvic girdles and the extensors of the back. The examination of clinic patients of the weak and inefficient type, the "constitutional failure," the person who knows himself inefficient, and the person who is inefficient but does not know it, all of these are found to show the physical conditions associated with the lack of the activities of these larger muscles. The muscles of the shoulder and pelvic girdles and the external back muscles are found flabby and without the normal tone. Many of these persons have the smaller muscles excessively contracted. The emergencies of life and the instructions of others induce them to endeavor to "brace up," and this results in the increased stimulation of the smaller muscles. The deeper layers of the back, the muscles of the face and the hands, fingers and feet show excessive contractions. The person is apt to suffer from the effects of the stiff spine thus produced, and the various visceral disturbances associated with the stiff spine do not increase his vigor or his sense of strength.

Use of the Extensors

The extensors are, as a rule, larger than the flexors.

The contractions of the extensor muscles are usually associated with a sense of well being and of energy, while the contraction of flexors is associated with the sense of diminished environment and of personal inadequacy. How much these conscious variations depend upon racial history and how much depend upon the physiological activities of the neurons directly we are not able to determine. The movements associated with the extension of the limbs do tend to increase the environment of the individual, and the flexion of the limbs does tend to decrease the environment. It may be that these reactions are merely the effect of racial history.

Education of the Weak

These factors may be employed in the education of children and of neurasthenic and hysterical patients. The use of exercises involving the extensor and abductor muscles may be taught in cases of children who are too self-centered and selfish, and cases of patients, especially the hysterical, who show too great egoism. Such patients and children should be taught to assume those positions associated with slightly increased extension, and especially those positions which are dependent upon the use of the larger muscles. The head well up, the legs strongly placed, the shoulders placed well, the fingers relaxed, the arms and feet slightly apart — in short, the attitude which is commonly recognized as giving the appearance of the broad-minded and generous person is the attitude which should be encouraged and taught to both children and adults who are inefficient, selfish, and of narrow mentality.

Bony Lesions in Etiology

The bony lesion has its place in modifying personality through the factors just mentioned. The person with an atlas lesion, for example, may be unable to hold his head comfortably without turning or depressing the face, or holding it in some other abnormal position. The very fact that he is placed in the position assumed under the influence of shame or fear causes the neurons concerned in the coördination of those emotions to have the lower liminal value. The impulses associated with his daily life are interpreted as shame or fear in increasing degree. The fact that his face is held in that position causes the people with whom he is associated to attribute to him those qualities, and they are apt to treat him accordingly. If the lesion, or the torticollis, is sufficiently pronounced to cause a position which is apparently an abnormal one, then he himself and the people with whom he is associated recognize the fact that an abnormality of physique and not an expression of character are responsible for the condition, and his mental make-up is less seriously affected.

Adenoids and Personality

The position assumed by the child suffering from adenoids is of a certain psychical importance. It is not altogether the deficient oxygenation of the blood and the deficient nutrition, the passage of the unwarmed and uncleansed air through the mouth to the lungs, which are responsible for the mental deficiency of these children. In part the position assumed by the mouth-breather, his hanging jaw and opened mouth, his loss of the normal tone of the temporal and masseter muscles, cause something of the same state of consciousness which is caused by actual inefficiency and the lack of decision. These factors are not alone in causing the abnormal mentality, but they are factors which must be considered.

The positions assumed by the body are efficient in modifying consciousness. They are efficient in modifying the physiological activities, circulatory and nutritive. They are concerned in perpetuating the effects of disease, under certain conditions, and the substitution of normal positions of the body for those abnormal positions which are habitual may be one factor in helping sick people to recovery.

Functions of Motor Areas

The essential function of these various activities of the primary sensory, overflow and intermediate areas is the control of the reactions which the body makes to its environment. The whole use of incoming sensory impulses, of the complex structure of neuronic activities which are associated with the complex and important phenomena of consciousness, of the coördinations concerned with what are commonly known as reason, science, judgment, art, and all the other complexities of mental life as we daily experience it, all have as their ultimate function the one thing, the modification of the activities, the control of the daily replies which we make to the environmental variations.

Value of Motor Impulses

This pragmatic view of the cortical activities is the physiological view. Those nerve impulses which are not, and can not be, associated with efferent impulses are useless, and, in the effects which they may produce within the nervous system, may be harmful. The recognition of this fact has been unduly delayed among those who teach both the young and the old. It has a place in the determination of the methods to be employed in the care of those who are sick as well as in the training of the well.

Deeds a Criterion

Moral, and ethical, and philosophical writings everywhere, among all races and all centuries, wherever civilization has attained a sufficient development for philosophy, and ethics, and morals to be considered, have been, and are being, filled with the importance of doing, the inefficiency of merely thinking or merely hearing, and the great value of deeds as the basis for real merit, real living, real service. It must be understood that the ultimate value of the activity of the entire nervous system lies in the fact of added efficiency of the motor reactions. The various philosophical and ethical systems have this truth in common, and it is sound physiological truth, as well as sound logic, and ethics, and religion.

The recognition of this truth and its adoption in meeting daily emergencies simplifies the whole matter of living. It makes the line between the valuable and the useless in attainments and thought fairly clear, and it diminishes the necessity for any of those morbid introspection processes which sometimes interfere with the normal activities of hyper-conscientious people. All of the looking into one's own emotional states, all of the analysis of feelings and weighing of motives, is seen to be useless and wasteful unless the motor reactions may be modified by such introspection.

So long as unimpeded impulses produce wise and kindly motor reactions, with no consciousness of impending unwise and unkind motor reactions, there is no need to assume anything but a wise and kindly personality. The first condition is that by which we judge the personality of others; both are properly concerned in judgments of ourselves. An unfortunate egoism causes people of a neurasthenic type to consider only the second condition in judging themselves; they refer to their own consciousness for the proof of their own righteousness. Introspection is rarely of value. Consciousness is affected by the activity of the cortical neurons, and these are subject to variations in their physiological conditions, such as rest or fatigue, good blood or bad, lack of oxygen or plenty, normal pressure of the blood or excessively high or low pressure, and a number of other things. Evidently, the knowledge gained by introspection concerning the value of life must be poorly founded. The proof of the value of life comes from a recognition of the value of deeds; the proof of the righteousness of any person's life is found in the value of his service to his fellow man. His service may be concrete and be felt directly; it may be found in his power to add to the value of the lives of others. Directly or indirectly, it is in deeds that the measure of personal worth must be found.

Determination

Sensory impulses which reach the cortical centers usually affect the overflow and intermediate areas, and the efficient reply to this stimulus follows, either as an actual motion produced through the agency of the primary motor area, or as a variation in the cells of the motor overflow, by means of which the results of the series of nerve impulses affect future reactions. This activity of the cells of the motor overflow, by means of which future reactions are modified, is associated with the consciousness which is called "determination," or the "making up of one's mind." The modification of the cells of the motor overflow is comparable physiologically to the modification of the cells of the sensory overflow, by means of which the phenomena of memory are produced in consciousness. The determination process is a sort of inverted memory, if the expression may be permitted. By means of this physiological action the occurrences merely imagined may affect future reactions in very much the same manner as if the actual circumstances had occurred.

Educational Principles

In educating children, appeals are often made to the emotions and to the faculties of idealization. These appeals are dangerous when they are associated with no possibility of reaction.

In early childhood each sensory impulse should be permitted to be associated with some motor reaction. No sensory impulses should be associated with actual repression. Even painful sensation should initiate cries in the small child, as it does, as a matter of course. Too early attempts to educate the child to refrain from crying because of pain are unwise. As soon as it is possible to substitute some other reaction for crying, this may be done with beneficial educational effects. But some motor reaction ought to be permitted, during early childhood, for every sensory impulse which reaches the sensorium. The place of education at this stage of development is in establishing the habit of making a wise reaction, rather than a foolish one. If the child stumbles over a stone and hurts himself, it is not wise to cry or to try to punish the stone, as is the teaching of some mothers; but the wise reaction should be to attempt either the removal of the stone or the turning of the path, or some other action by means of which the probability of repeating the stumble may be avoided, both for himself and for others. Even very young children may be taught to make replies to even painful stimuli in some such manner as this, and the neuron systems concerned in making these altruistic reactions become developed in a way which makes the wise and kindly action habitual probably throughout life.

Development of Self-control

What is true of the sensory impulses is true of the more complex reactions associated with the emotional and instinctive states. When circumstances cause the reactions characteristic of fear, anger, etc., these reactions ought always be modified, to a certain extent, but never, in children, to be absolutely repressed. The reactions may be temporarily inhibited, and thus the impulses initiated by the activities of the cortical neuron systems may be permitted to modify the reaction, but any attempt at absolute repression is apt to be injurious. Anger may be thus inhibited, the impulses concerned in memories of previous kindnesses on the part of the offending person, of previous pleasures associated with the toy which fails to lend itself to the wishes of the child, or other memories or coördinations may be associated with the activities of the emotional neuron systems, and the ultimate reaction may thus be an expression of kindness or of help, rather than of anger. In fear, the temporary postponements of the reaction may be associated in like manner with various memories, coördinations, or teachings, and the reaction may become indicative of curiosity and interest rather than of unintelligent terror. In those uncontrollable terrors to which neurotic children are sometimes subject, no attempt at education should be made until the nervous system of the child has been brought to a more normal condition through the use of proper hygienic measures and the correction of whatever structural abnormalities may be present. The same thing is true of those furious fits of anger to which some children are subject. The best educational treatment for such children is simply to avoid all irritating circumstances until the nervous system becomes normal and the reflexes become less excessive. Then mild educational methods may be used, with careful avoidance of whatever is known to cause the storms, either of fright or anger, or of any other uncontrollable emotion.

Educational Use of the Motor Overflow

Teachers in school often endeavor to inculcate high ideals by appeals to the child's sense of what is true and beautiful, even beyond the child's capacity of appreciating these things. Such appeals, when they are made in a way which permits either the immediate performance of an appropriate reaction, or when an imagined reaction may be clearly brought into consciousness, by means of the activities of the motor overflow areas, may serve an excellent purpose in modifying the future reactions of the child during life. But such appeals, when not associated with the activities either of the primary motor area or its overflow, or are not expressed vividly in language, are dangerous as a source of abnormal inhibitions later in life.

Perhaps the average Sunday-school teacher is at fault as often as any one, so far as this matter is concerned. Most Sunday-school teachers seek to teach the children high ideals of life, and they do this by constantly appealing to what are usually called the higher emotions. Ideals of fine living, of self-sacrifice, of great and kindly helpfulness, are placed before the children in an abstract manner, which is not possibly associated with any motor impulses, either directly or indirectly. To lead children, or older people either, for that matter, to higher levels of living, it is necessary that they be induced to actually do or say, or determine to do or say, some real thing. Cortical activities associated with motor reactions are efficient for good if they are wisely determined, for ill if unwisely, but always efficient in the modification of character.

People who are grown may employ these methods in their own education. It must be remembered that feelings and aspirations which are not interpreted into action, either actual or determined, or into language, which is a form of action, have no real value as educational factors.

Therapeutic Considerations

In dealing with the sick, use may be made of the same methods. The appeals to the "better" sense, to the higher ideals of usefulness, to the desire for increased strength and ease, are of little value unless they are associated with some concrete action or determination. Through the eye, or the ear, or the sense of touch, or the sensations associated with increasing strength, impulses may be sent into the motor areas which cause increased activity of the primary motor area, and the consciousness of increasing strength is given, or the impulses may initiate increased activity of the cells of the motor overflow areas, and the consciousness of determination, of choice, of impending strength and recovery is compelled.

The patient's consciousness is of "making up his mind to get well," but it is the activity of the neuron systems concerned in the motor overflow areas, and especially of the larger pyramidal cells of the primary motor area, which cause this consciousness. The variations in the activity of these cortical neuron systems are as completely subject to the control of an efficient physician as are the various centers of the spinal cord. The stimulation of the motor overflow area, or the primary motor area, is as easily done, if one really tries, as is the stimulation of the heart center, or the increase of the peristaltic movements.

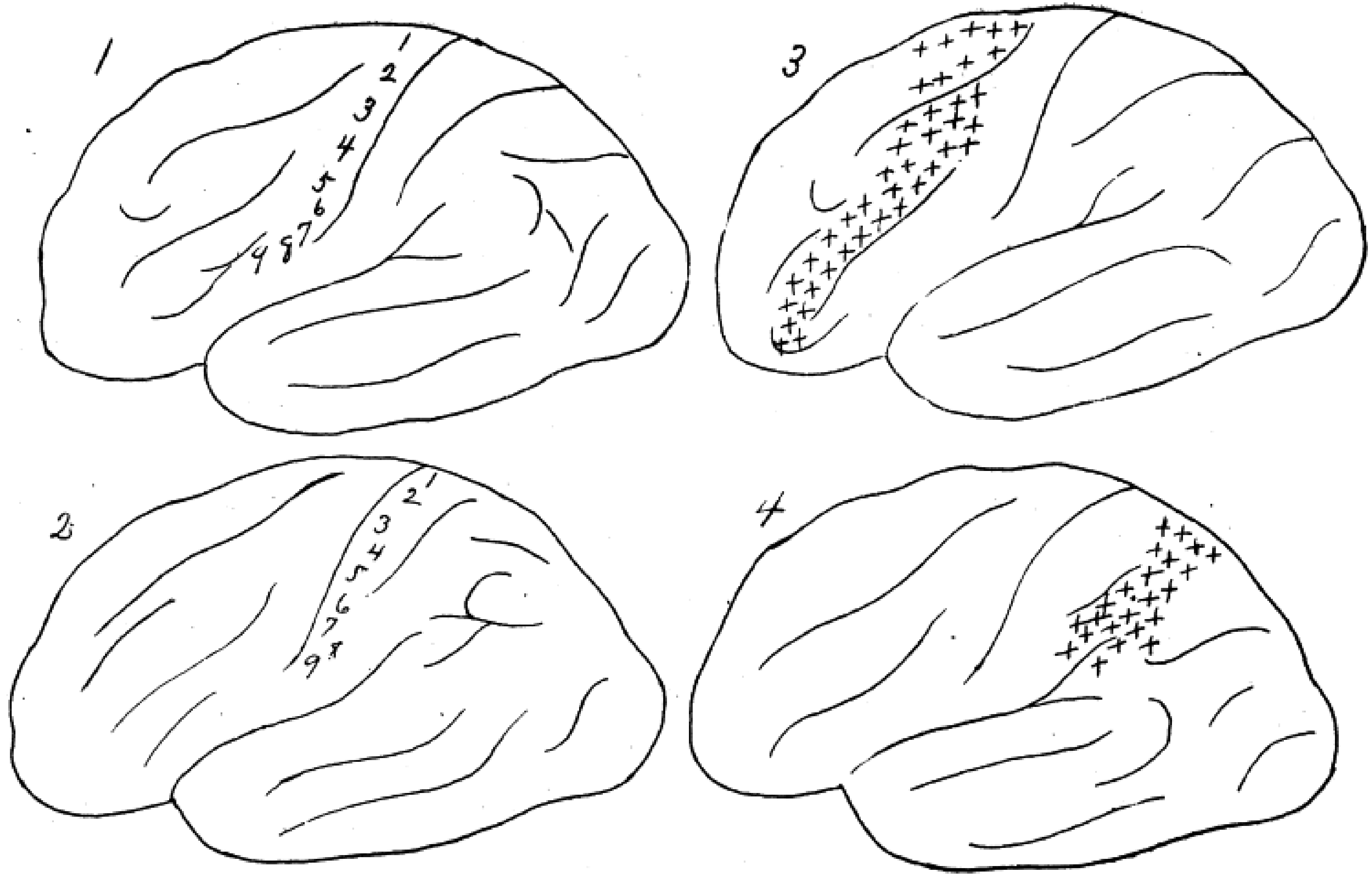

Fig. 13. Diagram of the sensori-motor areas.

1, Primary motor areas.—1, hip; 2, trunk; 3, shoulder; 4, arm; 5, wrist; 6, fingers; 7, face; 8, lips; 9, larynx.
2, Primary areas for common sensations. Numbers as in 1.
3, Motor overflow areas.
4, Overflow areas for the common sensations.

CHAPTER XI

LANGUAGE

The areas concerned in language include both sensory and motor areas. These areas of different but related function are found rather widely distributed over the cortex. They occupy parts of almost or quite all of the overflow areas, including certain areas in the right cortex as well as the left.

The Auditory Center

The auditory overflow extends posteriorly toward the occipital lobe, inferiorly on the surface of the temporal lobe, and upward toward the parietal lobe, from the posterior part of the temporal lobe. (Figs. 12, 14.) That part of the upper and middle temporal convolutions which is continuous with the anterior occipital lobe and the inferior parietal lobe of the left hemisphere is concerned in the memories of the sounds of words and of their significance. Injuries of this area cause loss of the power to understand spoken words, though no deafness is present. The person so injured has the same relationship to his mother tongue that normal people have to a foreign language. The words may be distinctly heard, but they have no significance. This area seems to be the one primarily developed in the beginning of the use of language. It is not well developed in idiots of the lower classes, among whom there is no possibility of learning to understand more than the simplest heard language. Lower-class idiots are not capable of using spoken language in the expression of thought, though they may use a few simple expressions indicative of their wants or their affectional states.

Very closely associated with the auditory language area is the motor language area. This occupies the foot of the third frontal convolution, or Broca's convolution, as it is called. This area lies within the motor overflow for the laryngeal muscles, and the muscles of the tongue, lips and face. The motor speech area is associated with the auditory speech area by the superior longitudinal fasciculus. This bundle is composed of the axons of cells of the auditory overflow, of the visual overflow and of the somesthetic overflow, as they pass to the frontal lobes, to form synapses with cells of the frontal cortex. By means of this bundle the cells stimulated by the memories of words and their significance are able to initiate the activity of the motor speech center at the foot of the third frontal convolution, as well as certain other adjacent areas to be mentioned later.

The Motor Speech Center

The motor speech center is developed with the beginning of active speech. The activity of this center must depend upon the activity of the auditory speech center. In disturbances of the motor speech center the person is able to remember how words sound, and he knows what words to use, but he is not able to coördinate the movements needed for their pronunciation. He is not able to think of the movements needful for the pronunciation; in other words, his motor speech memories are lost. (Fig. 14.)

Cases of actual paralysis of the speech muscles are recorded. In these cases speech is lost, but the motor memories remain. The patient is able, in these cases, to form a mental image of the movements needful for speech, but the movements are impossible. The cortical lesions found in such cases involve the inferior part of the precentral convolution.

In other cases paralysis of the muscles of the larynx, lips, tongue, etc., may be associated with injuries of the lower centers.

The motor speech center is concerned in the first use of language, in the normal person, and it is subject to stimulation by the other centers. At first, the development of the centers used in writing and in other forms of expression are initiated by way of the motor centers. As development of the secondary center proceeds, the activity of the first motor center is either not initiated by the transmission of impulses through it on the way to other centers, or the impulses come to be carried by other shorter paths, which do not include the original center. It is noticed in poorly-educated people, who write with difficulty, that the movements of the fingers are associated with movements of the lips, tongue, etc., which are concerned in the pronunciation of the words they are writing. This is true of children learning to write. It is only when the impulses concerned in writing have become able to travel a pathway which either does not include the motor speech center, or to traverse that center without causing its stimulation, that writing becomes easy and as if without thought for the act itself. This is, of course, the ideal of expression, that the means of expression should be apparently without thought, and that only the thing to be expressed should be represented in consciousness.

New Languages

There is certain clinic evidence that in learning a new language new neuron groups are functionally developed. At first, as new languages are usually taught, the impulses are carried by way of the older center to the neighboring neuron groups. This is the case in the process of increasing the vocabulary of the language already used. The new language is not to be considered as learned until it is possible to express thoughts by the use of the new language without reference to the old one. Thus, the habit of learning a new language by translating the words of the old language into the words of the new necessitates the transmission of the impulses underlying the thought to be expressed to the auditory speech center, then to the motor speech center, where are placed the cells for the coördination of the muscle movements of the words of the language already familiar; then the impulses must be sent from this center, either directly or, more probably, by way of the center for the memories of words heard again, to the neuron groups, themselves in the motor speech center, but somewhat removed from those already educated. All of this transmission of impulses requires time and nervous energy. In the process of this transmission the neuron activity concerned in the consciousness of the thing to be expressed is partly inhibited, and the thought suffers greatly from this loss of proper coördination. In this method of learning a new language it is hoped that ultimately the impulses concerned in the new motor speech center may come to be primarily initiated without reference to the centers concerned in the older speech movements. But this shortening of the paths requires a great deal of time, and under certain circumstances is never perfected.

The "Natural Method"

Recently the so-called "natural method" has been used in the teaching of new languages. The attempt is made to establish from the very first a relationship between the thought and the expression in the new words. No attempt is made to translate one language into another; in fact, all tendencies to such translation are discouraged. In teaching by this method the student sees an article and is told the name for it; sees performed, or himself performs, an act, and is told the word for the act; perceives qualities of any sort, and is told, and pronounces, the name for those qualities. In order to prevent the tendency to the translation of words from one language into the other, objects, qualities and acts with which the student is not familiar are chosen as much as possible at the beginning. Idiomatic expressions are employed in the beginning; these, of course, are not capable of literal translation. The economy of this system is apparent. No time is consumed in forming a series of paths by way of the old language centers to the new. Paths which must be finally eliminated if the new language is to become an efficient means of expression are not formed, but the connections between the ideas to be expressed and the motor impulses for their expression are made by the shortest possible pathway from the very first. The use of the new language learned in this way becomes easier, the idiomatic constructions seem simpler, and the person thus taught has better command of the new language than if he had been compelled to translate the new ideas into the old language first, then into the new.

In Therapeutics

The application of this question in therapeutics is apparent. In dealing with those people whose long illnesses have affected the tenor of their thoughts in such a way as to prevent normal mental activity, it is of little value to try to translate their present ideas into healthy expressions and thoughts. In such cases the wisest thing is to try to teach, as if from the beginning, the expression of new ideas. It is like learning a new language for these people to use the expression of cheerful, and pleasant, and wholesome ideas. They must be educated into the expression of useful and healthful ideas by means of wholesome activities, and the use of the words and expressions characteristic of the saner mentality.

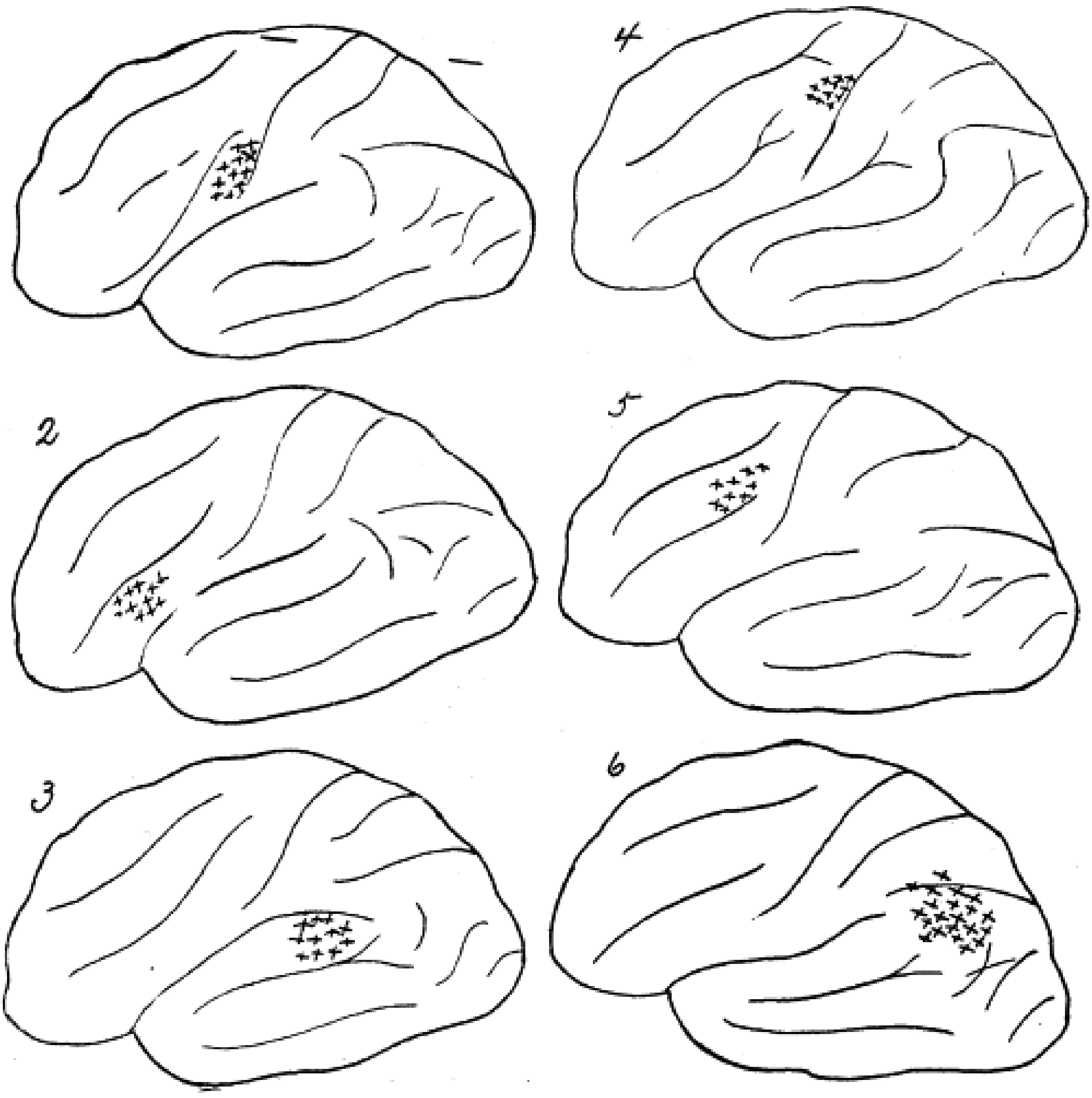

Fig. 14. The language centers.

1, Motor area for the muscles concerned in speech.
2, Speech center, for the co-ordination of the movements of the muscles of speech.
3, Center for the memories of heard words.
4, Primary motor area for the movements of the fingers, etc.
5, Writing center.
6, Center for the memories of seen words.

Visual Speech Center

The center for the memories of the appearances of words lies upon the occipital lobe, just posterior to the center for the memories of heard words; that is, in the left angular gyrus. Injury of this center causes visual sensory aphasia. The patient loses the power to recognize words as seen, though there is no true blindness. In uncomplicated cases the patient would yet be able to recognize the significance of words heard, but the proximity of the two centers renders uncomplicated cases of visual amnesia or of auditory amnesia extremely improbable. (Fig. 14.)

These two centers are as intimately related in function as they are in location. Both are essential to the performance of the normal writing movements. As in the case of learning a new language, however, the methods of teaching writing should depend as little as possible upon an endeavor to translate the vocal motor speeech impulses into the writing motor impulses. The endeavor should be to develop the coördinate activity of each center independently.

The motor center for writing lies near the foot of the second frontal convolution. Lesion of this area is associated with a loss of the power to write, though the power to read things written is not lost. (Fig. 14.) The muscles of the hands and fingers are not paralyzed. The only loss is of the power to coördinate the movements in such a way as to produce written words. This loss of coördination, in one of Gordinier's cases, did not affect the ability of the patient (a woman) to knit. She was able to hold her pen properly and to make movements which looked as if she were writing, but only unrelated curves were produced by the movements. The memories for the appearance of the words and the power to read intelligently, both silently and aloud, were not injured. The lesion was found, at autopsy, to involve only the foot of the second frontal convolution.

Naming Center

The angular gyrus of the right hemisphere is concerned in the memories of the uses, and perhaps also of the names, of objects. Injuries of this area cause mind-blindness. Objects are distinctly seen, but are not recognized; their names are not known and their uses can not be remembered. The condition may be associated with word-blindness, or it may be uncomplicated. The intimate association of the lateral areas renders uncomplicated cases rather rare.

In all of the centers concerned in language certain physiological factors are to be considered. The normal activity of any one of these centers depends, to a certain extent, upon the normal condition of the others. Rarely, lesions are localized in centers which are functionally somewhat independent. In such cases exact localization is possible, and the symptoms are very instructive in the determination of the functions of the different cortical areas. Clinically, the relationship is often found more complex. Lesions extend from part of one center into part of another, and the symptoms are correspondingly complex.

Stammering

The normal activity of the speech centers, as of the other parts of the cortex, depends upon the maintenance of the normal nutritive conditions, and upon the normal relationship of the sensory, associational and motor impulses. It often occurs that the action of these centers, especially of the motor speech center, is incoördinated. This may result from any one or more of a number of different causes.

Children who have been made self-conscious and awkward by excessive criticism, especially of an unkind nature, often begin to stammer. This is due to the inhibitory effect of the overstimulated frontal centers. Such inhibitions affect the speech centers in such a manner as to postpone the activity of certain neurons, while the stream of impulses associated with the idea to be expressed stimulates the same center to increased activity. Hence the irregular and incoördinated movements of the vocal muscles may be caused.

Emotional states affect the speech mechanism adversely. The inhibitory impulses from the basal centers may be so powerful as to inhibit completely the power of speech. This is especially true of spoken language, though the same effect may be found in written language at times.

Stammering may be caused from the presence of certain peripheral irritations. Abnormal sensory impulses may reach the cortex from almost any part of the body in such numbers or such force as to affect the entire cortical activity. Increased irritability results from excessive stimulation, in the absence of exhaustion, and the increase in irritability causes increased activity under slight stimulation. The inhibitory impulses mentioned in connection with the results of excessive adverse criticism are present as a result of excessive sensory stimulation.

The presence of poisons in the blood stream, eye strain, overwork, excessive responsibility in children, and a number of other sources of abnormal functional activity on the part of the cortical neurons may be efficient factors in perpetuating the stammering habit.

The cure of stammering must depend upon the removal of the abnormal nervous irritations, if any are present, and the education of the centers.

The educational processes to be considered are, first, the establishment of the normal relationship between the centers, and, second, the removal of the inhibitory impulses. The members of the family of the person who stammers should not pay attention to the habit, since this increases the inhibitory impulses. If the educational methods must be used by some member of the family, the teaching should be given by one person only, at certain stated times each day. Indiscriminate criticism is much worse than if no attention were given to the condition at all.

The stammering person should be taught, first of all, to recognize vividly in consciousness the actions which he performs in the endeavor to speak. He should stand before a mirror, at first in the presence of the doctor who has his case in hand, and should watch himself trying to talk. He should do this until he is able to see clearly exactly what manner of motions he is performing. This should be done in as kindly a manner as possible; no ridicule should be permitted, and no person should be present except those who must be. Preferably only the doctor in charge of the case should be with the child when instruction is being given, especially at the first.

The conscious recognition of the nature of the facial movements being secured, they may be inhibited voluntarily to a very great extent. He should imitate voluntarily the movements, again and again, until he can imitate his own facial contortions. What he is able to do, voluntarily and consciously, he is able to refrain from doing. If he is unable to refrain from the incoördinated movements, he is not yet able to perform them well. Usually the production in consciousness of stammering movements is enough to cure the habit. If necessary, however, the movements concerned in normal speech should be practiced before the mirror until it is possible to talk without any facial contortions. The methods of scanning, of sing-song speech, of singing and of rhyming lessen the inhibitory impulses from other cortical centers, and are of a certain value in helping the stammerer to self-confidence and to right habits.

The person in whom the speech centers have been acting in an incoördinated manner for any length of time is very apt to have a certain amount of difficulty in speech under emotional stress or times of fatigue for all his life. If this knowledge inculcates a certain amount of self-control, perhaps no great harm is apt to result from the slight impediment.

It must be noted that the motor speech center occupies part of the third frontal convolution, that the writing center occupies part of the second frontal convolution, and that the visual overflow and the auditory overflow are all concerned very markedly in the nervous mechanism of language. The naming of words, objects, actions and qualities makes the language mechanism associated with practically all of the cortical areas. So intimately is this language mechanism associated with other parts of the cortex that the most efficient activity of the cortical neurons depends upon the exactness and efficiency of the naming process.

Myths

In myths of every people whose myths have been studied in this connection there are found accounts of the efficiency of this naming process. In most myths there is a ferocious monster, or some devil, or some malevolent creature who assails, or attacks, or harasses a person or a country. Some wise or brave person calls him fairly and plainly by name, whereupon the malicious creature disappears with a howl, or the devil with an odor of brimstone, or the monster may commit suicide. The fact that giving a name to that which is a cause of disturbance lessens the cause for fear has its root in the fact that the naming process, relating, as it does, so many cortical areas, is associated with more efficient cortical activity, and thus with clearer consciousness than would be possible in the absence of language.

Clear Language Makes Clear Thoughts

Exact naming is one factor in securing vivid consciousness of sensory impulses, thus in appreciating the facts of environment and their significance. The use of words of doubtful meaning, or words which have different uses, without a clear understanding of the manner in which they are being used at any given time, the distortion of words from their commonly accepted significance, the endeavor to employ other terms for the sake of euphony, careless language at any time, all of these things make clear thinking, efficient activity of the cortical neurons, practically impossible. Only as spades are called spades is their use in digging clearly appreciated; only as a wrong is clearly seen can it be righted; only as faults are recognized and named can they be eliminated. The monsters of the myths were destroyed only by calling them by name; the monsters of our civilization, of our government, of our profession, of our individual lives, can be destroyed by calling them by name, and in no other manner.

In the old myths, the good fairies, the benevolent gods, the helpful angels, were to be called to one's assistance if only one knew their right names. All the good things of life were held to be at the disposal of the person who was able to call by a true name the spirit who had them in charge. This, too, is a truth. If the things which are desired are called by their right names, the manner of securing them usually becomes evident. It is true that things become often less desirable when they are called by their right names. But desires which are truly and exactly expressed become by that very fact rather more attainable, or their impossibility becomes more certainly evident. The exact naming of ideals, of earnest desires, of the objects of enthusiasm, is the first long step toward their attainment.

Educational Principles

In the teaching of children the most important factor to be considered in language is that they shall use words in their exact sense. Many words have more than one meaning; children must be taught to discriminate, and to know in what significance they employ the word. The time of childhood is the time for the teaching of the foreign languages and for the establishment of a large vocabulary. There is a certain educational value in the process of learning a new language. The use of the different neuron groups gives a broader field for the associational activities. The use of the vocabularies associated with the different vocations of life is of similar value, but this is less efficient than the use of the new language. The development of different neuron systems which is secured by the attainment of a new language is not to be found in any other line of education.

In the training of the mentally deficient, attempts should be made to increase the vocabulary in as great a degree as is consistent with the powers of the child to understand the words. The words chosen must always be those for which a clear use is possible, and the child must use them in their exact sense. The more vividly the words can be appreciated in consciousness, and the more exactly the expressions can fit the thought to be expressed, the better is the educational value of the language in the development of the mental capacities.

Therapeutic Uses

The use of language as an educational factor in therapeutics is fairly evident. When people are for a long time sick they are apt to become accustomed to answering those foolish questions concerning health which politeness seems to demand by a detailed and more or less truthful account of their sufferings. Now, the very fact of detailing symptoms lowers the liminal value of the neurons concerned in the appreciation of the discomforts, and thus increases their irritability. So that every time the sick person tells his pains to his neighbors, he adds just so much to his own discomforts, he increases the tendency of his neighbor to suffer in the same way, and he postpones certainly the hour of his own recovery. The neighbor usually listens with only half an ear, since he usually is thinking of the pains he himself has suffered, and is getting his thoughts in order for their recital, or he may frankly be bored by the uninteresting tale. This lack of sympathy does a certain amount of good, that it prevents too great an amount of the psychical contagion of suffering.

Such people may need nothing in all the world so much as to forget their discomforts, and yet this is the most impossible thing for them to do. "I never allow myself to think of my sufferings, no matter how bad I feel. I just make myself forget it." People who talk in that way are remembering, and suffering, and making themselves suffer all the day and most of the night. No one can ever forget by determination. The only forgetting comes by way of new and different remembering. If any one would empty a pail of air, he would best do this by filling it with water. The cortical neurons are constantly active. It is impossible to voluntarily prohibit the activity of any particular group of neurons. The neuron groups are stimulated according to their relative liminal values. If any neuron group has the lower liminal value, it is more affected by incoming stimuli. If it is desired to lower the liminal value of other and antagonistic groups of neurons, this is easily done. But it is probably impossible to increase directly the liminal value of neuron groups. So it is of little value to try to teach such people to try to forget their sufferings; they must actually forget them in the use of other neuron groups.

It seems to be very successful in some cases to compel the patient to actually lie himself out of his pain. But there must be some lack of normal conditions in the person who is thus able to lie to himself, and the effect of deliberate self-deceit must be harmful.

This attitude is unnecessary. There are enough good things in the world to think about without devising false things which are merely supposed to be good. Let the ideas of personal comfort or discomfort alone. It is not good even to attend to bodily sensations long enough to deny them. Let them alone. Let the patient attend carefully to things outside of his own bodily condition and tell others about them. Let him put into words everything which he can find which concerns things strong, and fine, and beautiful. He must not try to think himself well, or talk about himself as well, but he may think of himself as going to work, as engaging in some line of endeavor in which he is interested. He may plan for the future as much as he will, but he should cease at once and absolutely any consideration of his present feelings, either good or bad. He must answer the questions the doctor asks, but to every one else the question of personal sensations should be tabooed. Why should it be polite to ask after a person's health any more than after his bank account?

Persons who are ill for any length of time should be absolutely forbidden to answer any questions concerning their bodily states, or to permit others to talk about the subject of health or sickness.

After recovery seems fairly well advanced, it may seem advisable to permit the expressions of strength and good health. The expressions of interest in work or play must always be of greater value than expressions of returning health, however good this may be.

The best thing in the world for such people is for them to begin to plan for the future. Make them talk about the future, about the things they are planning. Make them talk about the emergencies which they may meet, and how they will meet them. Make them use the larger muscles, as has been explained in a previous chapter. Make them talk even about other people, if they can not be interested in things better fit for conversation. Better the most exaggerated village gossip than talk about their own physical conditions.

Summary

Physiologically, language serves much the same purpose which is served by muscular movements. It gives expression to the nerve impulses arising from the activity of the ganglionar centers and the intermediate areas, and thus eliminates the harm of the repressed emotions and judgments. The development of the neurons of the language centers makes possible the storing of memories and determinations in a more exact and powerful manner than is possible in the absence of language. In education and in therapeutics the language centers may be used as efficiently as are the other cortical or the ganglionar centers. In treating certain diseases characterized by mental symptoms the language centers may be employed, as osteopaths already are employing the spinal centers, for the modification of nervous activity, and thus, indirectly, for the improvement of the bodily state.

CHAPTER XII

RELATIONS OF SOMATIC AND CEREBRAL PROCESSES.

The phenomena ordinarily considered as indicative of the control of the body by the mental states are interpreted in physiology as being the effects produced upon the bodily activities by the activities of the cortical and ganglionar neurons.

The activities of these neurons cause certain variations in consciousness, but this effect in consciousness is probably the effect of the cortical activity rather than its cause. It is, of course, not possible to prove that this is true, but such a supposition explains more simply the facts of mind-brain physiology than any hypothesis yet offered.

The experiments described in this chapter are given as being suggestive rather than conclusive. More exact methods of investigation and tests made upon a greater number of subjects must be employed in the determination of the actual relationship between the cortical and the somatic activities.

In order to determine, if possible, whether variations in the time occupied by mental processes might result from somatic variations, a series of tests was made. The method used for the determination of the reaction time was a modification of certain methods used by Hugo Münsterburg.

Experiments

Many experiments were made in the endeavor to find some method of determining the exact reaction time for each reply. The difficulties were greater than the exigencies of the case warranted. The variation in the time necessary for the reply to any single word was not the intent in this connection. We were seeking the physiological relationships, and not the particular psychical significance of different words.

After experiments into the methods best adapted to the case, it was decided to use lists of one hundred words as a standard, to determine the time required for the pronunciation of these words by some person whose duty it should be to read the lists, ascertain the time required for the subject of the test to pronounce one hundred words, and the sum of these times is considered the pronunciation time for the two people. The pronunciation time does not vary greatly for any one person at different times, but it does vary for different people.

In making the test, the subject assumed a comfortable position, and another person was supplied with lists of one hundred words of a quality decided upon for the special tests. Each word was pronounced, then the subject gave in reply some other word which was suggested by the word heard. The next word was then pronounced, another reply given, and so on until one hundred words and usually one hundred replies were given. Occasionally the word was met by a confused "I do not know any word." The time required for the pronouncing of the words and the giving of replies, less the time required for the pronunciation of the one hundred words by both persons (two hundred words in all), is supposed to represent one hundred simple association processes in the brain of the person making the replies. It is, of course, not possible to determine that this is actually true. It is probably, however, a fairly true measure of the relative speed of the association processes.

The Bony Lesion

In the first series of tests the place of the bony lesion in the variation of the speed of the association processes was studied. The normal reaction time was taken first, and usually the blood pressure and heart rate also were determined. The subject then received steady pressure at the side of the second thoracic spine for five minutes. The reaction time was again taken during the five minutes, at the end of five minutes, and again five minutes after the pressure was discontinued. The lists of words used in this series of tests are those given as simple words on another page.

Twelve people, normal and not weary, were employed in these tests. None of them knew what reaction was expected, but all knew that the investigations were in regard to the bony lesions and the speed of mental processes. The tests were repeated several times, on different days, for each subject. It was found in all cases that when the blood pressure was increased by the lesion, the reaction time was decreased. The increase of blood pressure, in the case of the second thoracic, seemed to be associated with increased pulse rate. The pulse was increased by as much as eight beats per minute; the blood pressure increased as much as twenty m.m. of mercury. In most cases the increase in pulse rate and blood pressure was none at all or very little. The reaction time decreased with increasing blood pressure. The reaction time decreased as much as .2 sec. on each word.

When the pressure, imitating the bony lesions, remained longer present, or when the pressure was followed at once by lowered blood pressure, the reaction time increased. The decrease of blood pressure was as much as twenty-five m.m. of mercury; the increase in the reaction time was as much as .08 sec. per word.

That is, the increased blood pressure was associated with increased speed of association, and decreased blood pressure was associated with decreased speed of association processes.

The next series of tests studied the lesion of the eighth thoracic vertebræ. The conditions were as before. Nine subjects were used, and the tests were repeated upon them several times on different days.

The results verified those given in the first series. When the pressure was so applied as to lower the blood pressure, the reaction time was increased; when the pressure was painful, or when the placing of the fingers caused stimulating movements, then the blood pressure went up and the reaction time was decreased.

Blood Pressure

A number of tests were made under varying conditions to determine whether the blood-pressure changes was the constant factor. The blood pressure was raised by stimulating movements applied to the splanchnic centers, by exercise, by muscular tension, by drinking freely of water, by eating moderately of food, and in all cases in which no source of error was found, the increase of blood pressure was associated with decreased reaction time.

Conversely, the blood pressure was lowered by pressure in the region of the splanchnic centers, by lying quietly upon a table, by relaxing the muscles voluntarily, and in other ways. Whatever lowered the blood pressure, in the normal person, increased the reaction time — that is, decreased the speed of the association processes.

One report of a patient who was subject for the test may be given. The lesion was a left anterior malposition of the atlas. The patient complained of a dull, stupid headache. Pulse, 60; respiration, 20; blood pressure, 114 m.m.; reaction time, 3.6 sec.

Dynamometer: right hand, 125, 105, 130; left hand, 119, 111, 118.

The atlas was corrected by the use of very gentle movements. No pain was felt, no "pop" was elicited. Relief from headache was experienced immediately.

Within a few minutes after the lesion had been corrected the tests were repeated.

Pulse, 62; respiration, 24; blood pressure, 100 m.m. (ten minutes later, 120 m.m.); reaction time, 2.8 sec.

Dynamometer: right hand, 128, 118, 135; left hand, 128, 118, 112.

In a number of other clinic cases the reaction time alone was tested. Correction of the lesion was often followed by a temporary lowering of blood pressure and increased reaction time, but this was followed, usually within ten or fifteen minutes, by increased blood pressure and decreased reaction time.

Causes of Variations

Other somatic causes of variation in the reaction time were noted:

Fatigue increases the reaction time.

Autointoxication increases the reaction time.

Fasting decreases the reaction time at first, then increases it as weakness supervenes.

After mental effort, as after an examination, the reaction time is increased; sometimes it was twice the normal reaction time.

Six people were chosen for a series of tests upon the effects of the bony lesion upon the time required for more complex coördinations. The same subjects were used for the different tests, which were given on different days.

The tests were as follows:

1. Columns of figures were prepared, and the subject was asked to add them as rapidly as possible, putting down the sum obtained at the expiration of one minute.

2. Lists of words were prepared; each subject was told to give as many synonyms as possible during each minute.

3. Questions necessitating considerable thought were given; the character of the replies was noted.

For the most part, the results of these tests were identical with the results given for the simpler coördinations. Bony lesions which lower the blood pressure increase the time necessary for the cortical coördinations; bony lesions which raise the blood pressure, in the normal persons who were subjects for the tests, decreased the time required for the coördinations. But the number of errors was larger in the results of the tests made under the increased blood pressure.

So far as the third test was concerned, there was considerable individual variation. While it seemed fairly evident that the lowering of the blood pressure increased the time and decreased the character of the coördinations, the effects of the increased blood pressure were very contradictory. Further study is needed.

Affectional Variations

The character of the replies given to the lists of simple words varied according to physiological conditions. When the blood pressure was lowered experimentally the replies included a larger number of words of unhappy significance than under normal conditions. For example, "day" was more apt to suggest "cloudy" or "dull" when the blood pressure was low, or when the subject suffered from autointoxication, or any other subnormal condition, than at other times. The word "day" suggested "sunny," or "bright," or "happy" more often when the blood pressure was normally high, and when the physiological condition of the subject was good.

In a few clinic patients who suffered from arteriosclerosis there was melancholia present. The blood pressure, already abnormally high, was sometimes increased as the result of too strenuous movements employed in the correction of lesions. When this occurred, the melancholia was increased. It seems evident that the normally high pressure is associated with such a condition of the cortical neurons that happy and pleasant replies are most readily brought into consciousness. Under abnormal conditions, as in the excessively high or the excessively low blood pressure, the cortical activities were so modified that the unhealthy and morbid reactions were more apt to occur.

Neurasthenics

Several neurasthenics were treated during these tests. The blood pressure was uniformly low in the patients treated at that time, though neurasthenic blood pressure is not always low. It was very interesting to note the lessening of hypochondria in the conversation before and after the administration of the necessary corrective movements in such a way as to raise the blood pressure. The hypochondria was apt to recur, of course, as soon as the blood pressure decreased again. But while it stayed up the patient had at least some respite from the "blues."

For convenience sake the words are prepared in lists of fifty, and two such lists give one hundred words. Simple lists are as follows:

dark	white	man	rough	broad
keen	warm	mug	fresh	fast
stiff	stern	late	strong	weak
false	just	horse	sweet	flow
vast	cat	sing	wool	skill
test	moon	ship	east	live
pun	bloom	coin	out	lake
feet	dust	lark	vein	side
bank	head	face	red	king
pint	green	send	room	break

SOMATIC AND CEREBRAL PROCESSES

Diagnosis

In experimenting upon clinic patients, it has been found that those ideas associated with certain abnormal conditions are most apt to recur in replies. Lists of words significant of the disorder from which the patient fancies himself suffering have the shorter reaction time. This peculiarity is most noticeable in neurasthenic or psychasthenic patients. In ordinary conversation it may be noticed that the replies and answers are much more rapid when the subjects related to the patient's ideas of his illness are being discussed than when other subjects are under consideration. This condition is due, doubtless, in part to the fact that these patients have used those neuron groups concerned in the coördination and recognition of abnormal conditions so frequently that they have the lower liminal value, and are thus easily stimulated by all sorts of sensory impulses, and in part to the other fact that this very condition of self-centered egoism is one factor in producing the ills from which they suffer. However the condition is produced, the apparent reaction time may be employed in the diagnosis of certain abnormal factors in the functional neuroses.

Effects of Ideas Upon Somatic Conditions

Another series of tests was made in the effort to determine whether any effect could be produced upon the bodily activities by ideas entering the sensorium. The first series included tests made upon about a hundred people, and with repeated tests upon a few individuals.

Effects of Gloomy Ideas

The blood pressure, pulse, respiratory movements, reaction time and dynamometer tests were taken, then words from one of the "gloomy" lists were pronounced, and the subject asked to give a synonym or related word in answer. Fifty words are usually about as much as the average person wishes to endure in such a test. The results of these experiments may be grouped as follows:

Blood pressure decreased, sometimes by thirty or forty m.m., but usually ten or fifteen m.m. of mercury.

Pulse decreased, with occasional irregularities.

Respiratory movements become irregular, sometimes with frequent sighings.

Reaction time increased, sometimes almost doubled, for gloomy words; the usual increase is about .5 sec. per word.

Dynamometer tests show decrease of strength of both hands, but especially the right, during and after the pronunciation and replies of the "gloomy" list.

The gloomy lists are about as follows:

dark	sorrow	dull	ill	weak
weight	dark	mean	blue	sad
alone	faded	timid	forlorn	labor
silent	stupid	fatal	shroud	grave
weeping	aches	weary	poor	old
lazy	worry	falter	dying	sickness
peevish	torn	worry	hopeless	heavy
broken	sorry	grief	tears	pity
hard	moody	failure	restless	sleepy
silly	false	frozen	tomb	decay

A few people who were subject to slight hypochondria were employed as subjects. The gloomy list had not the least effect upon their physiological activities. Apparently the gloomy trend of thought is usual with them.

Effects of Cheerful Ideas

Lists of cheerful words were provided. The effect of the pronunciation and replying of the cheerful lists is not marked in normal people. Usually no differences are manifest in the use of the ideas which are, probably, the normal thoughts of sane and wholesome cortical activities. People who are fatigued, or sick, or suffering from the effects of bony lesions may be affected by the use of the cheerful lists sometimes. It is evident that no permanent good could be accomplished by the use of cheerful ideas as a method of therapy if the lesions, or the autointoxication, or any other physical factor is permitted to remain uncorrected. The cheerful lists are about as follows:

lovely	cheery	gladly	happy	smiling
freely	gaily	roses	lively	gleeful
jolly	helpful	cordial	pretty	music
funny	hoping	bliss	vigorous	favor
nimble	easy	sunny	golden	mercy
rosy	merry	glisten	jovial	jest
playful	shining	banter	benign	glorious
singing	swiftly	melody	lucky	wealthy
kindly	caress	fair	picnic	feasting
frolic	blithe	splendid	dancing	joyful

After the gloomy words have been used, the person returns to the normal condition rather more quickly if the cheerful list is given than if he is simply left to recover. But the normal person is not long affected by even the most gloomy of lists.

Another series of words are those associated with inefficiency. Lazy, worthless, stupid, careless, etc., make up such a list. The reaction time is greater than normal when such words are used, but the effect on the circulation does not seem so pronounced as in the case of the gloomy lists.

Effects of Scientific Terms

Lists made up of scientific terms do not seem to affect the bodily activities so much as do other lists, but they have a long reaction time. Such words are, molecule, calyx, neuron, embolus, plexus, afferent, veratrine, solstice, parallax, etc., make up these lists. Sometimes the blood pressure is raised. Since such terms have no particular emotional coloring, it is not strange that no particular physiological reaction should follow their use.

Effects of Forceful Ideas

Another list of words which raises the blood pressure and usually affects the pulse is made of words indicative of strength and effort. Such words are, supreme, domineering, forcible, energy, determine, achievement, momentum, etc. The use of such words in the most desultory manner seems to cause the slight muscular contractions indicative of physical activity. Dynamometer tests usually show increased muscular strength after such lists have been given.

Effects of Mental Effort

Urgent mental effort, as in the endeavor to add long columns rapidly, or to solve difficult problems mentally, seems to affect bodily activities differently in different people. Of a hundred and seventeen people subjected to the test, a few displayed no blood-pressure variations which were perceptible. About sixty-five had the blood pressure increased during urgent mental endeavor. It is found that the greater is the increase of the blood pressure during mental effort, the greater is the muscular contraction associated with the effort. About thirty people showed a lower blood pressure during mental effort. It is not usually easy to find indications of muscular effort in the endeavor to concentrate the attention in those whose blood pressure decreases during mental effort.

Effects of Passive Ideas

A number of tests were made by pronouncing the words to the subject who was asked to listen to the words, but not to make any reply. The variations in these cases were about the same as described for the other tests, in which the words were pronounced and replies of associated words given.

Short stories involving emotional colorings were used also. The association processes of different individuals interfered somewhat with these experiments. For example, a story of horror was used in one experiment which was based upon the attack of a ferocious lion. The subject of the test began laughing, and explained the matter by telling of a ridiculous occurrence which he himself had experienced.

Effects of Repressed Ideas

The association of certain words with experiences of an emotional coloring leads to changes in the blood pressure and pulse rate of the subject when such words are pronounced. In a number of cases certain individuals used as subjects decided upon something which should be kept secret. While the pulse and blood pressure were being watched, another person pronounced words to the subjects. The variations in pulse, blood pressure, and sometimes the size of the pupils, indicated which of the words pronounced were related to the ideas chosen for concealment. When the experiments were carefully performed, it was usually possible to determine what the nature of the chosen secret was, and sometimes to determine in considerable detail rather complex stories. Individual peculiarities and experiences modify the results to a certain extent. In one case, for example, the subject really was holding secret certain plans for an entertainment; these plans appeared in the indications determined by the study of the various somatic changes associated with the effects of the pronounced words. It would be rather dangerous for the person with a "skeleton in the closet" to act as subject in such experiments.

Diagnosis

These reactions have a certain value in diagnosis. If any person is trying to conceal anything from the physician, the pulse shows the effects of disturbance when anything suggestive of the concealed circumstances is mentioned. Even if the thing itself has been forgotten, any suggestion of what has been associated with emotional states has an effect upon the pulse. Thus, the factors of etiology which the patient himself has forgotten may be brought to mind again by watching the pulse while conversation, apparently impersonal, is being carried on. Lists of words may be used, but the device is very evident, and often is associated with an increased self-consciousness, which lessens the value of the information secured in this way. It is a very good plan to keep the fingers upon the pulse while the history of the patient is being taken, with especial attention to the variations on the blood pressure. While the proper instructions are being given as to diet, etc., the pulse is apt to show any beginnings of obstinacy. People often have excellent control of the facial muscles, of the motions of the hands or feet, and their statements are often modified by their own interpretation of their symptoms, so that conclusions based upon facial expression and subjective symptoms must be supported by exact knowledge. The method of securing more truthful information is no substitute for laboratory methods of diagnosis. Yet, since no person can exercise control of the blood pressure at will, the information gained through judicious watching of the pulse is usually fairly well to be depended upon.

Summary

In summing up the histories of these experiments the following conclusions appear to be evident:

1. Variations from the normal physiological conditions of the brain increases the time required for simple or for complex coördinations.

2. Within normal limits, the increase of blood pressure

decreases the time required for either simple or complex coördinations.

3. Under slightly abnormal conditions the tendency to the recurrence of ideas of a depressed significance appears in most cases.

4. Ideas associated with depressed emotional or affective states tend to lower the blood pressure and to decrease the muscular strength, as measured by the dynamometer.

5. Ideas with no emotional or affective significance do not affect somatic activities in so pronounced a manner as do the ideas which are concerned in the emotional or affectional states.

Environment and the Emotional Reactions

The place of the ganglionar centers of the cerebrum in the coördination of the emotional reactions has already been discussed. The activities of these centers, among lower animals, control those reactions which are concerned in the preservation of the life either of the individual or the race. Among human beings the activities of the centers are, or should be, controlled by the descending impulses from the cortical centers; in other words, the memories, judgments and ideas resulting from the coördination of memories and judgments, as in anticipation, should control the emotions. This is especially true among people whose cortical centers are functional in the highest degree — that is, among people of normal inheritance, and history, and environment.

Among people of abnormal inheritance, individual history or environment, among degenerates, neurotics, and those whose lives have been spent among abnormal surroundings, there is a lack of the normal development of the cortical centers, and the lower centers thus assume an unduly important place in the control of the motor activities of the individual. The cortical centers are somewhat active in probably all but the lower classes of imbeciles and the idiots, but the cortical neurons are less normally coördinated in activity. Certain neuron groups may be developed to an excessive degree, while others remain practically inactive. Thus the unbalanced mentality results which is found among criminals, the feeble-minded, and the neurotics of all classes of society.

Cold Weather Crimes

During the cold months the crimes of an emotional nature are lessened. The cold weather necessitates the use of more food, more clothing, and an expense for lodging and fire. The cold weather is a time of lessened income on the part of those who live by the sins of others. Both of these factors are responsible for the increased prevalence of robbery and the murders for the sake of robbery during the cold months. Suicides are more rare, and the suicides which do occur seem to be the result of poverty or of a determination previously considered, rather than the result of sudden impulse. Autointoxication is less prevalent during cold months, with the increased oxygenation processes; and even the use of alcoholic drinks is less injurious during the cold weather than during the hot months. Also, there is less temptation to the use of stimulants, as a rule, during cold weather.

The nature of the crimes committed by individuals as a class, and the nature of the insanities prevalent among people as a whole, depend, to a certain extent, upon climatic and other environmental conditions.

Effects of Hot Weather

Even normal people are affected to a certain extent by changes in the seasons and in the weather. But normal people are not so affected by hot weather as to become insane, to commit suicide or murder, or permit themselves to become affected in any injurious way by the variations in climatic conditions.

Students of criminology have found that the seasonal variations exert a very noticeable effect upon the character and number of crimes committed in cities and in countries over the world. Statistics are mostly based upon the crime records of cities.

During the hot months, and during unseasonably hot weather in other months, the crimes which are based upon the ungoverned action of emotional states are most prevalent. The reasons for this condition are somewhat complex.

Physiological Relations

First, it must be recognized that the neurons of the cortex, whose activity is concerned in the inhibition of lower centers, the coördination of memories and the formation of judgments, are of later phylogenetic development, of more unstable metabolism, and more easily affected by abnormal circulatory and toxic conditions than are the older and more stable neurons of the ganglionar centers. Thus, in the presence of poisons in the circulating blood, or of abnormal pressure of the blood, or of any other condition which interferes with the nutrition of the nervous system, the neurons of the intermediate areas are first affected, the neurons of the sensory overflow areas are next affected, while the primary sense areas and the ganglionar centers remain active and their efficiency seems increased by the lack of the inhibitions of the cortical neurons. Thus, the tendency is always present for emotional storms to be associated with temporary or permanent loss of normal cortical activities.

During excessively hot weather, especially with high humidity, the increased perspiration leads to an excessive concentration of the blood serum. The activity of the kidneys and the liver in the elimination of metabolic wastes is thus lessened. Autointoxication is present in some degree. The increased metabolism necessitated by the higher temperature and the increased action of sweat glands, together with the lessened oxygenation of the blood, lead to oxygen starvation, and to the presence of excessive amounts of the fatigue products in the blood stream. The concentration of the blood by the increased elimination of sweat decreases also the digestive fluids, and the absorption and digestion of the foods taken is lessened. In hot weather the action of bacteria upon foodstuffs is increased, and a certain amount of poisoning, not always sufficient to be recognized as such, may be present. All of these conditions are present in increased degree among the very poor of the large cities.

The fatigue and the increased perspiration lead to the increased consumption of alcoholic drinks. This, also, is a source of further inefficiency on the part of the cortical neurons. The drug addictions also are of more severe influence during the hot months. The lack of proper bathing facilities among the very poor, the increased perspiration of both human beings and animals, the increased rapidity of bacterial growths, with the associated putrefaction and fermentation processes, all add to the presence of odors in the poorer and dirtier parts of the cities. These odors add greatly, though unconsciously, to the emotional instability.

Reproduction of species is associated with the beginning of the warm months. The increase in sexual desires is associated with the beginning of the warm months, both normally and abnormally. The tendency to sexual crimes in spring and summer is recognized by criminologists.

The direct and the indirect effects of hot weather are toward the increased irritability of the neurons of the ganglionar centers and the decreased efficiency of the cortical centers. The emotional reactions are thus left more or less uncontrolled, according to the development of the persons studied. Normal people, with normally developed cortical centers, are not injured by climatic changes. Those whose cortical neurons are not sufficiently developed to remain functional during climatic and other environmental changes are those from whom the prisons and the insane asylums are constantly filled.

Nature of Crime

Given the emotional instability, the environmental and somatic conditions determine the nature of the crime or insanity which may result. The person whose attempts to earn a living are inefficient, or who has been disappointed in any one of many ways, suffering from autointoxication or starvation, may commit suicide. Another person who may be affected by other environmental changes may commit murder. It is probable that differences of blood pressure may account for the fact that one person, disappointed in love, for example, may commit suicide, while another may murder his rival and his sweetheart. The emotional instability is the real root of these abnormalities. Whether an insanity, a suicide, a murder, or some sexual crime results, depends entirely upon the chance occurrences of the environment, or the somatic condition of the person so afflicted.

Punishments

It is evident that punishments, as the term is generally used, are of no value in dealing with such conditions. The present tendency to substitute reformatories for prisons is a move in the right direction, so far as the treatment of present criminals is concerned. But sociologists must solve the problem, finally, by removing the ultimate causes of the abnormal emotional instability, and physicians must add their work in the line of securing better physical conditions, of increasing the physiological development of the race, and thus in giving the cortical neurons the conditions needed for their normal and efficient activity. As curative and preventive measures punishments may be used, but punishments given as punishments, in the sense of hurting the criminal because he has hurt some other person, as a sort of revenge and a way of "getting even with him," are of value only in adding to the probability of his repeating his offenses with the skill of his previous experiences. Given a government seeking revenge, the criminal seeks revenge also.

Prevention of Crime

The life of any criminal is not very long. Criminals of the degenerate type have short lives. Criminals of a sudden temptation are curable; they may live long, and fine, and efficient lives if the rational means of treatment are employed and they are given normal surroundings. But the real problem lies in the prevention of the conditions which perpetuate crime. This is the problem which confronts every physician daily. That baby which is poorly nourished is more apt to be criminal than he would be with proper food. That child which is being dosed with stimulating medicines is more apt to be criminal than he would be if he were treated by rational methods. That child in school, with adenoids, slightly deaf, is in the midst of an environment in which he is misunderstood and mistreated. He hears poorly, but is expected to act as other children act; he sees the injustice, and is growing into a criminal or an inefficient. That other child, with cervical lesions, is growing into a malcontent or worse because of the injury which is being thus produced. Osteopathy has this to consider, that no child treated by osteopathic means can be sent into manhood or womanhood with the injuries produced by the action of stimulants upon the developing neurons.

Causes of Instability

Another cause of emotional instability lies in the presence of the peripheral irritations. This is more pronounced in the genital region. Worms in the intestinal tract may be efficient causes of irritability, as may also be the gastric disorders. But most efficient of all causes of instability are the irritation caused by the hooded clitoris, phimosis, scar tissue around the cervix or perineum, tumors of the pelvic organs, urethral caruncles, hemorrhoids, anal abnormalities, the enlarged prostate, and the hundred and one other disorders to which the pelvic tissues are subject. The impulses from these abnormalities are not usually represented very vividly in consciousness, but they are carried to the centers of the cerebral ganglia, where they are able to affect the neurons concerned in the control of the emotional reactions. The lowering of the liminal value of the lower centers thus produced increases the tendency to emotional instability, and the person so affected may be seriously injured thereby.

The effects of climatic variations upon people who are sick is commonly recognized. In dealing with neurotic individuals, it is necessary to take into careful account the environmental conditions. Factors which the normal person is able to disregard altogether, or to meet with a fair degree of equanimity, the neurotic person is not able to deal with at all. He must, during his recovery, be placed in a position where no sources of irritation are apt to reach him. It is useless to ask the neuropathic individual to control himself; he has nothing to control himself with until the cortical neurons are permitted to recover. No causes of irritation should be allowed to reach him until a certain time has elapsed during which good blood is flowing at a normal pressure through his brain, and a stream of normal nerve impulses is being permitted to act upon the neurons of the cortical intermediate areas.

CHAPTER XIII

EDUCATION IN THERAPEUTICS.

People who are sick in any way are usually sick in many ways. The unity of the body in sickness and in health is one of the things easiest to teach and easiest to forget. Many centuries ago Marcus Aurelius wrote, "What is good for the bee is good for the hive," and this is as true for the parts of the body physical as it is of the body politic. The evils which afflict one part of the body do not long leave any other part of the body in its best working order. The mentality suffers ultimately in all disorders, and the symptoms should receive the same attention given to other symptoms in the treatment of the patient. This is not saying that sick people are imbecile or insane; it is only saying that the physiological activity of the cortical neurons depends upon the same conditions as does the physiological activity of the other cells of the body. As it is not probable that the glands, or muscles, or the spinal centers act normally in the absence of the good blood, flowing freely, and the nerve impulses normal to them, so the neurons of the cortex are unable to act normally in the absence of good blood flowing freely, and the nerve impulses normal to them. Osteopaths use the condition of the spinal neurons in the diagnosis of disease. The presence of excessive irritability of certain spinal centers is held indicative of certain abnormalities. So, it is possible to see in certain mental peculiarities the indications of certain abnormalities of structure or of function. The cause of the peculiar mental condition of the patient should be studied as other symptoms are studied, and the information thus gained may be used in diagnosis, just as the information gained in the study of other symptoms is used.

Osteopaths study the condition of the spinal centers constantly in diagnosis, and make use of the various nerve connections to increase or decrease the nerve impulses to different viscera. It is just as rational to study the relative irritability of the cortical centers, when these are acting abnormally, and to increase or decrease their activity according to the needs of the individual patient. The study of the variations in the activities of the cortical centers and the modification of their activities through rational and physiological means, is as essentially osteopathic as is the study of the variations in the activities of the spinal centers, and the modification of their activities by rational and physiological methods.

Causes of Insanity

The causes of abnormal activities of the cortical neurons may be considered briefly. The gross structural degenerations associated with the insanities need not concern us at this time, since these are incurable. The functional disturbances associated with the insanities must be studied in insane asylums and sanitariums for a long time before any statements may be made concerning their treatment from the osteopathic standpoint. It is greatly to be desired that some osteopath may be associated with such institutions and study the cases with reference to the osteopathic viewpoint, and thus our knowledge concerning the pathology and treatment of such cases be increased.

With a few exceptions, our knowledge is limited to the study of the borderland cases, and to the mental characteristics of certain diseases, not to be classed properly as insanities.

The neurasthenic, the hysterical and the neurotic individuals are to be considered in the light of the physiological activities of the cortical neurons. These persons are found everywhere, and their proper treatment is one of the most perplexing of problems.

Inheritance

Many patients of the neurotic type are such because of a faulty inheritance. The neurotic inheritance includes hysteria, excessive irritability of temper, migraine, epilepsy, tuberculosis, marasmus, rachitis, alcohol and drug addictions, and, indeed, whatever makes for poor nutrition or nervous instability. It is probable that it is less the actual use of alcohol or drugs which makes the bad inheritance as it is the nervous abnormality which renders the excessive use of such stimulants possible. Individuals whose ancestors include the drunkard, the epileptic, the hysterical, the bad-tempered, and the subject of migraine, as well as of the grosser insanities, are more liable to the neuroses and the psychoses. These persons may live fairly normal lives as long as they are placed under fairly normal conditions; but any overwork, or the use of stimulants, or any of the exhausting diseases, may injure them in much greater degree than is the case with the normal person under the same conditions. Physicians need to recognize these neurotic persons, and to insist with urgency upon their living quiet lives under the most favorable conditions. Children born of neurotic parents must not be subjected to any overwork at school, must live quietly, out of doors, with much work of a normal kind, no excitement, and with only the normal and well-balanced mental and nervous activities permitted them.

These neurotic individuals usually appear in the physician's office suffering from "nervous prostration" or some other euphonious disease. Unfortunately, such patients do not respond very well to ordinary methods; the diagnosis is not easy, and too frequently they are simply sent from one doctor to another, with no very careful study of their cases anywhere. Their instability of character is in part responsible for this constant changing from one doctor to another, and from one fad to another, and from fad to philosophy, and from philosophy to fanatic, and from fanatic to physician again. Many of these patients are hopelessly unsane — not insane, but simply without sanity. The condition of such people should be recognized and their relatives informed of it, so that no expense need be incurred in useless attempts at cure. Others, and this includes most of such cases, are capable of being helped to lives of comparative usefulness. Others yet can be persuaded to be treated rationally, and they may recover apparently completely.

Diagnosis

In studying these cases it is necessary to determine what centers of the cortex or basal ganglia have been subjected to overuse, or which have been left undeveloped. The usual methods of examination usually show the unbalanced relationships existing in certain regions. Ordinary conversation along unplanned lines, letting the patient follow his own tendencies, often throws light upon his peculiarities. The omissions should be noted, as well as his statements. The fingers upon the pulse will often note circulatory disturbances when some subject with an emotional bearing is broached. The variations in blood pressure should also be noted.

Questions concerning his past life, and especially of his life of about the time the "nervousness" first appeared, sometimes help in fixing the nature of his mental processes. Questions regarding his views upon governmental and religious affairs, his social and club relationships, show whether he is excessively self-centered or not, and whether any tendency to an abnormal emotional instability exists.

Classes of Neurasthenics

Most such cases fall into one of four classes:

The patient who has been overworked in truth, and whose neurons are generally fatigued, has the symptoms called neurasthenic. There are no particular localization symptoms present. No excessive egoism and emotional shock are to be found even upon close questioning. The history includes an amount of overwork in excess of that which the normal individual should endure. The tests for muscular strength, reaction time, etc., are characteristic of the neurasthenic. The spinal column is almost invariably flat, with a lack of the normal mobility either throughout or extending through certain areas. The place of the immobile areas differs according to the habits of the patient. These patients do well under the ordinary methods of treatment. They must have their condition explained to them, must have lessened amounts of work, and must be well fed. They usually do best without sharply-marked variations from the usual habits of life, but in certain cases the complete change is needful. Their habits must be studied, drugs omitted, foods easily digestible and nutritious substituted for abnormal foods, and dietetic fads subjected to scrutiny. Such people are often half-starved by their addiction to fads, or they are half-poisoned by their use of abnormal and indigestible foods.

The second class of patients includes those who have suffered some long illness, and have recovered to a certain extent, but not altogether. Such people are often those who have been treated by certain drugs. When the nerve impulses concerned in the consciousness of pain, or weakness, or inability have been frequently initiated, the neuron systems concerned in carrying these impulses, and in coördinating the reactions initiated by them, become more and more irritable, so that after a time even the nerve impulses initiated by the commonest environmental changes initiate the activity of the pain-carrying system of neurons. Persons who have been subject to long illnesses, especially of an exhausting nature, or not associated with any loss of consciousness, are apt to continue to feel the sensations of pain and weakness, and to express this feeling, long after the tissues of the body itself have regained their normal condition. When the person affected in this way is surrounded by sympathetic friends, who are constantly warning him against "overdoing himself," or when he has "nothing to do but just to get well," this condition may be perpetuated almost indefinitely. Almost as bad is the patient who has no sympathy, whom "nobody understands how I suffer," and who meets with constant advice to "forget it" and "make an effort" and "try to do some good to other people," and other advice, which is about as well adapted to the needs of the case as if a blind person were told to look at a picture.

The third group of patients includes those who have, at some time in their lives, been subjected to some condition which has excessively lowered the liminal value of certain groups of neurons, so that the impulses initiated by the ordinary affairs of life exert an effect upon the activities of the cortical and the ganglionar centers which is injurious in a marked degree. These patients usually display the stigmata and crises of hysteria, and many peculiar phenomena are found associated with their processes of consciousness at times. The prognosis in such cases is good, with proper treatment.

The fourth class of cases includes a number of those in whom only slight evidence of abnormal heredity is found, who have been subject to some overwork, not excessive, who have used some drugs, have suffered from some sexual excesses, and who give accounts of complex symptom groups. The complications of such patients are many, and it is sometimes impossible to make any exact diagnosis.

In all classes of neurotic patients there is apt to be found an unbalanced egotism, or at least egoism. The peculiar symptoms of each case need to be studied and treated in connection with the special case, and without much reference to classes or pathology.

In all of these cases the diagnosis must include the complete study of each patient. Many cases of Meniere's disease, of incipient paresis, of nephritis, of heart lesions, of pernicious anemia, of tuberculosis, begin with symptoms similar to those described. The fact that any person is neurasthenic or hysterical is no reason why there may not be tuberculosis, or a brain tumor, or pelvic abnormality, or hemorrhoids, or any other disease, in fact. The examination of the patient who has been passed around from one doctor to another should be at least as thorough as the examination of the patient who has not that discouraging history.

Treating Neurasthenics

The physician must consider only the needs of his patient in this matter. It is his duty to place the patient in the best possible condition to do good work; and while he may, as a friend of the patient and as a member of society, use his influence to encourage the brave, and wise, and kindly attitude toward life, he must never permit his endeavors along these lines to interfere with his more urgent duty as a physician, and this is, that he give his patient the very best possible body; for the body is the first and most urgent care of the physician, and in securing the very best possible bodily conditions, the first necessity for the very best possible attitude toward life is secured — the first step toward fine, and wise, and kindly living is made.

The brain cells which are normal, which are well fed with good, clean blood flowing rapidly through them, under normally high pressure, brain cells which receive from the body and its surroundings a constant stream of the sensory impulses needed for their normal activity, such brain cells as these act normally, which is to say, wisely and happily, causing by their activity the consciousness of work well done, of emergencies well met, of problems of existence well handled. If there is apparent in the attitude of any patient a lack of these qualities, an appearance of inability to meet the daily demands of life, if there seems lack of the joy in living, then it is the duty of the physician to determine the causes of this cerebral inefficiency. It is not for him to make a hasty diagnosis of a deficiency in mentality. He must find the physical abnormality underlying the mental ineptitude. Some efficient factor underlying the conscious ineptitude is always present. It may be found in a faulty education, and in this case the physical nature of the patient may also be affected. But in practically every case in which the more superficial study renders the diagnosis of faulty education as the only etiological factor, a more careful study will display the symptoms of a physical cause underlying the faulty mental activity. It must be held, more and more, that the activity of the normal brain is an activity which is associated with mental stability, with energetic living, and with the activities concerned in happiness and sanity. The lack of sanity and happiness, the presence of ennui, and worry, and dread are not compatible with the functioning of a normal brain, well fed and well drained of its wastes.

It is the duty of the physician to find this physiological factor in all cases. He must leave no stone unturned in the search for the physical cause of the disease. He may not consider himself justified in engaging to care for any patient unless he recognizes some underlying condition which he may hope by his care to alleviate.

True, there may be cases in which the educational factor alone is concerned. These cases are becoming apparently fewer as our knowledge of diagnosis increases.

Egoism

Though not a matter of certainty the conclusion is fairly enough drawn that the unbalanced development of the frontal cortex, and the excessive development of the relations between this part of the brain and other areas, must be associated with an unbalanced personality. The person of undue egotism, as well as the one of undue lack of self-appreciation. probably suffers from an unbalanced relationship between the frontal areas and other parts of the cortex.

An excess of egoism is the consciousness which is caused by a lowered liminal value of the left frontal intermediate area, so that the activity of other cortical areas initiates the stimulation of these neurons; in other words, the environmental changes and the results of the activities of the association areas are perceived in the light of personal experiences in excessive degree.

These persons may be intensely egotistical and selfish, but they may merely be egoistical. The condition is not exclusive of marked self-sacrifice. The person who comes often in contact with suffering may constantly be affected by the presence of "such misery, and I can do nothing." The very endeavor to relieve the suffering brings about a constantly-increasing sense of desire to help and a sense of helplessness. So long as such a person retains good physical health, so long will the wholesome reactions occur in other cortical areas. But when such a person suffers from overwork, or some neurasthenic or hysterical tendency, then the self-centered sense of helplessness is apt to be associated with the unbalanced reactions, and the tendency to help others becomes only a source of self-injury.

The man who supports his family may be anxious to supply them with increasing luxuries. He may constantly dwell upon his desire to make better provision for them, and he may be so persuaded that only his own efforts prevent disaster to those unable to earn a living that he, in time of overwork or indigestion, or an attack of grippe, or some other exhausting condition, may become morbidly egoistic.

The person who has been long ill, especially with certain diseases, may become self-centered to a morbid degree. Such a one translates every environmental variation into terms of his own physiological processes.

The only child, the center of the life of the house, in the very nature of things becomes egoistic early in life. Almost all children pass through a stage of genuine egotism at the time when the anterior intermediate areas begin to act more energetically. This occurs at about the age of puberty. The "spoiled child" is not necessarily the one who has the things he wishes, but it is the one whose attention has been too early directed to his own personality. This may be done as easily in the imposition of hardship as in the imposition of ease and luxury. It is not the number of dresses a little girl owns, nor the material of which they are made, that makes her vain; it is the number of times she looks in the glass, and the number of times during which she is compelled to attend to her own personality. Children who grow up in the midst of attention, whether the attention be of admiration or of fault-finding, are apt to be extremely egoistical throughout life, and to suffer from the ills which must be associated with such a temperament.

When we recognize the structural basis of this unbalanced idea of personality, the cure is already indicated. First, of course, must be considered the securing of the good blood flowing under normal pressure to the cortical neurons. It is not to be expected that any amount of stimulation can make ill-fed and half-poisoned neurons assume normal relationships.

Educational Treatment

Having provided the conditions needful for normal activity of the neurons, it becomes desirable to send into the cortical centers those impulses which will bring into activity the neurons of the posterior intermediate areas.

The posterior intermediate area lies between the motor, visual and auditory overflows. The auditory and visual areas are already related thoroughly with the anterior intermediate area. So, unless the auditory and visual stimuli can be so well chosen as to compel their coördination in the posterior area, it is better to use the motor overflow in the process, at first, at any rate. It is not usual for motor impulses to be so very intimately associated with the activity of the anterior association area. Probably this is, in part, because of the lack of any direct association tract between the motor area and the frontal lobes, and in part because in all probability there are many efferent impulses from the frontal lobes which are carried by the fronto-pontal tracts, and thus the motor cortical area is not concerned in the reaction to any great extent.

For these reasons, as well as for others which are apparent, the motor area may be chosen as the starting point of a new series of neuronic associations. No attention need to be paid to the person's consciousness, or his feelings, or any of those things. If he has enough confidence in the doctor to obey the instructions, that is enough to begin on. The chief thing is to get him to use the motor area, and to obey instructions. He must have no choice as to especial movements, but it is important he learn to do as he is told. The personal factor must be eliminated as far as possible. Exercises may be chosen which add to his physical strength, if this seems desirable for the particular patient. He may assume some other person's duties, if that seems best. He may be encouraged to walk a certain distance, if that seems best. If it is in any way possible, walk or the duties or the exercises should be planned to have an altruistic basis; no self-sacrifice should be imposed, for that makes the matter worse. The thing to do is to send sensory impulses essentially related to other persons or things into the cortical centers, in such a way that the motor impulses will result without bringing into activity any more of the anterior neuron systems than is unavoidable. The motor impulses should be exaggerated. He should be constantly directed to attend to his work or his walk. If he is an eye-minded person, make him write an account of his walk, and read it aloud to some member of his family.. If he is ear-minded, make him hunt for any interesting objects which may be found in the vicinity. Let him bring to you, or to some one who has, or pretends to have, an interest in them, the stones, shells, leaves, bugs, or what not, which he finds. Let him grow radishes, if he can, or chickens, or take photographs, or engage in any wholesome sport. Games are rather apt to inculcate the self-idea; camera shooting, or fishing, or any sport without emulation is better than golf or tennis, though these have their places in the treatment of certain cases. The underlying principle is simply this, to make use of the motor areas in answer to sensory impulses which have almost or quite no personal relationship, and to compel the use of the larger muscles of the body.

Use of the Stereognostic Sense

The stereognostic sense also is practically unrelated to the anterior intermediate areas. This center may be used for beginning the neuronic relations. Let the patient be blindfolded, and then let him handle familiar objects and name them. It is surprising how many mistakes will be made by a person who has not been accustomed to doing this, and especially by those who are egoistic. The association tracts are not well developed between these areas, and the egoistic person finds himself in a manner cut off from his accustomed paths. Fatigue results readily in the use of such tests, so only a few minutes should be employed in this manner. A similar series of exercises consists in putting a limb of the blindfolded person in a certain position, then having him place the opposite limb in the same position. Or he may be told to repeat a series of movements first passively given. Or he may not be blindfolded, and may imitate the movements of some person standing before him.

At first such methods appear trivial. But if it is worth while to spend time trying to loosen tightened ligaments which are doing harm, is it not fully as important to loosen the effects of abnormally irritable neuron groups which are doing harm? If it is worth while to work for the sake of strengthening a muscle group, why is it not worth while to work for the strengthening of a neuron group? The underlying principles are the same, and when the essential etiological factor lies in the functional relationship between neuron groups, then the only rational treatment is to modify these relationships.

Eye Brained and Ear Brained

Under normal conditions the association processes which are concerned in the activities called intellectual depend for their original stimulation upon the auditory or the visual impulses. Probably in the complete absence of these stimuli no mentality worthy of the name could be produced. At once such a statement suggests the names of Helen Kellar and

Laura Bridgman, who attained such great mental heights in the absence of auditory or visual impulses. But it must be remembered that neither of these persons attained any mental activity worthy of the name until the mental successes or normal people were imposed upon the vacant association areas. Normal brains employed the common sensory and olfactory and gustatory areas of the brains of these deficient persons as a sort of gateway through which language and the associations normally dependent upon audition and vision were carried into their consciousness. In such cases as these, the sensory overflow probably includes large areas of what would, in normal people, be included as auditory and visual overflow.

Among normal people there is found great difference in the development of the overflow areas and the development of the relationship between the overflow areas and the intermediate areas.

This difference appears the more conspicuously when the visual and auditory relationships are taken into account, though a similar series of differences exists between each of these and the so-called common sensations or the muscular sensation. People whose auditory coördinations and associations are most efficient are said to be "ear brained"; those whose visual associations are best developed and most efficient are said to be "eye brained." The terms are old, and have been applied in the sense of these being an underlying mental factor rather than a physiological one at the root of the phenomenon.

Why it is that the visual coördinations are best developed in one person and the auditory in another it is impossible to say. Probably a number of factors enter into the problem, such as an inherited neuron structure, accidental use of one area rather than the other during the time of most rapid development, circulatory changes, and other physiological or environmental conditions.

Education

In education the attempt should be made to develop both the auditory and visual overflow neurons to as great a degree as possible. This is done by the use of the familiar methods of encouraging students to express ideas both by spoken and written words, and to give instruction by means of spoken, written and printed words. Other methods of instruction and of expressions, as the use of pictures, the examination of natural objects, gestures, picture-writing, modeling, singing, manual training, and every other method which employs different cortical areas, either in the reception of an idea, in the coördination of the impulses arising from any stimulation, or in the expression of an idea by forms of motor activity, are to be encouraged as a means of developing the association neurons as fully as possible. The more freely the different overflow areas communicate, the more efficiently will the reactions of any individual answer his environmental demands.

In dealing with neurotic patients, a certain use may be made of these considerations. If the patient is eye minded, then he is more apt to understand and to obey written or printed instructions. He is more apt to state the really important points of his symptoms if he writes them. It is a good thing, in dealing with an eye-minded neurasthenic, to ask him to write exactly his feelings and symptoms — just once, of course. This takes something of the place of the "catharsis" so often commended in certain lines of therapeutics; the important points are apt to be stated; the physician can use his own discretion as to the amount of his own time that is occupied in the reading of the records; the written record should be kept with the records of the physical examination, laboratory tests, etc., of the case. Many interesting lights upon the cortical processes of such patients are to be secured by means of the written records of those patients whose mentality is suitable. Such records made by the ear-minded patient are of less import, but are very interesting.

The ear-minded patient should receive his instructions by spoken words, and he should give his symptoms in like manner, at first. The development of the visual relationship must be secured later.

In both classes of patients appeals must be directed in the manner most impressive to the particular person. Figures of speech are most effective if visual images are employed for the eye minded and auditory images for the ear minded. If figures of speech and explanations can be made which employ the particular line of work or of pleasure in which the patient is most interested, he attends more actively and obeys more implicity than if new terms are employed, or unfamiliar illustrations are used. This is not because he chooses so to obey or to attend, but because his association processes are most complete among the centers most used in his previous experience.

The use of new association processes is often of value. If any person has become neurasthenic or hysterical or subject to any similar functional disturbances, it may be advisable to secure the activity of new neuron groups. This may be accomplished by sending the patient to some other surroundings, but even then he takes with him the same old brain, with the same old circles of association processes with their lowered liminal value. New scenes may be efficient, but they are not always so, and the complete change of habit so often advised in such cases may not be possible for reasons financial or otherwise. In the cases in which the change of scene is inadvisable, or when such measures have failed, it is sometimes possible to bring about the increased activity of new neuron groups, and thus "change the see-er instead of the see-n," as one patient expressed it.

This change may be brought about in any one of many ways. If the patient is eye minded, he may be encouraged to read aloud, to attend lectures and concerts under certain conditions, to try to secure phonographic records of the songs of birds or the sounds which animals make, or of the wind or the waves on the seashore. He may be set to getting photographs of interesting scenes in the vicinity, and these scenes must be planned for some specific purpose. Usually it is very stupid work to take pictures simply for the fun of spoiling films. Anything which makes the eye-minded person use his ears, or use his eyes in a new manner, or which leads him to employ new groups of motor neurons, gives him the same physiological effects as the change of scene, with much less discomfort and expense, provided he can be induced to give enough energy and time to the new pursuits to educate the new neuron groups to increased efficiency.

It is much easier to plan the change of activity for the ear-minded person. He may be encouraged to copy certain chosen essays or articles. He may be asked to do these things as a favor to some other person, or as a sort of lesson for himself. Such things should be simple, easily understood, and short. The tasks may be graded according to the mental possibilities of the patient. The intelligent person may be asked to give his opinion of certain articles. Others may be encouraged to draw, to study pictures, to study flowers, or bees or moths, or any other thing in which it is any way possible to interest him. Children may be set to hunting four-leaved clovers, or small stones of different colors and shapes, or any other new task which necessitates out-of-door exercise. Any new fad may be encouraged. If other members of the family can be induced to coöperate in encouraging complete change in conversation, habits, etc., it is possible to develop new cortical relationships in a degree sufficient to secure the rest of the old association groups and assist very materially in the process of recovery. It must not be forgotten in dealing with this aspect of any case that the maintenance of a normal circulation through the injured brain cells, the providing of good, clean blood, the correction of whatever structural abnormalities may be present, and the securing of hygienic habits, are all of first importance. These things being secured, however, the use of the new association groups is of a very real value in hastening recovery from the neurasthenic states, and in providing the wider relationships for nerve action which prevent the recurrence of the trouble.

In treating diseases caused by a lack of use of certain muscle groups, the treatment must include putting those muscle groups into action. If any bodily disease is due to poor circulation, the rational treatment must include the correction of whatever causes the poor circulation. If some factor perpetuates irritation, that factor must be removed.

In treating cases associated with abnormal mental factors, the treatment must be based upon the same principles. First, the true condition of the patient must be recognized. It would be foolish to spend a great time treating any person whose cortex has been incurably diseased, or which has been deficient from birth. No one thinks of trying to treat a deformed part of the body into a normal structure, or to treat the body so as to make a new arm or leg grow to replace a lost one. So it is of practically no use to assume that in cases of actual structural degeneration, or of deficient development, the patient can be made into a normal person. All that can be done in such cases is to make the best of what capacity the patient does have, and to try to place him where he will be comfortable and as useful as conditions permit.

The Inhibitions

The place of the inhibitions in normal activities has been discussed elsewhere. It may be remembered that the inhibitions are probably the result of the withholding of the nerve impulses by transmitting them from the cortical cells, the small pyramids, the inverted cells to the cortex, and then by their transmission again through the same or a similar circle, until the impulses from other areas are able to modify the resultant action. Under certain abnormal conditions the impulses from areas concerned in the consciousness and the expression of pain and weakness and of unhygienic habits may have a lowered liminal value, so that the sensations concerned in the consciousness of well-being, or directions concerning hygienic living, are met by such violent inhibitions as to become practically worthless. Such patients do not obey the directions of the physician, though they may intend to do so, and may promise to do so with every appearance of their good intentions. Yet they do not one thing they are told, because the inhibitory impulses from the centers of the lower liminal value are more efficient than the memories of the words of the physician. It is possible to employ methods of instruction which are efficient in spite of these inhibitions.

The inhibitory impulses are initiated chiefly by the motor and the intermediate areas. When the motor and intermediate areas are less active, then the inhibitory impulses are less active. The motor areas are less active when the person has his muscles most relaxed. The intermediate areas are less active when the person has a slightly lowered blood pressure. If the osteopathic treatment is given first, and, after the necessary corrective movements have been given, the pulse is found to be slightly slower, and the blood pressure lower than before, if the result of the corrective movements has been to secure a feeling of restfulness, and the muscles of the spine and neck especially are well relaxed, then any instructions may be given without arousing antagonism in as marked degree as would be the case before the treatment had been given. The patient, perfectly conscious, and in no way hypnotized, in the ordinary sense of the term, yet listens better and accepts the instructions better, and believes what is said to him more implicitly than under ordinary conditions. Children, especially, are much more obedient under such conditions than they are after they are up and ready to doubt and consider.

Securing Obedience

By far the larger number of patients seek advice because they want to get well, and obey the instructions they ask for, and usually pay for, because they wish the benefit of the physician's knowledge and skill. But certain persons, usually neurotics, are so subject to their own inhibitions that with the best of intentions they are unable to obey. In dealing with these use should be made of the manner of instruction suggested. The important point is to give the directions and instructions when the muscles are relaxed and the blood pressure is low.

When any patient persists in any habit which is injuring him, the same methods may be used. It may be that the habit is too strong for him to overcome under ordinary conditions. Even if he knows perfectly well the consequences of that habit, the physician must repeat those consequences to him with every figure of speech and every manner of language possible to add to the effectiveness of what he is saying. If anything can be said which brings disgusting images into relationship with the abnormal habit, that should be said. After this the effects of stopping the habit should be described in even more vigorous language. The good things waiting for the patient upon his recovery should be described most vividly. Whatever he desires most greatly, whatever he admires most, and whatever appeals to him on the highest grounds, should be employed in association with the good things waiting for him when he has broken that bad habit. No promises should be made, unless the physician is in a position to grant them, but the attempt should be made to associate the activities of the cortical neurons concerned in the consciousness of good things with the activities of the cortical neurons concerned in the performance of certain actions, or the inhibition of other actions.

Such methods are not open to any criticism, as are the hypnotic methods; they can not be of harm, they lead to no bad after effects, they are perfectly consistent with the truths of physiology, and are in the same class with the correction of bony or muscular lesions in the relief of bodily diseases.

Right Naming of Fears

In dealing with patients who are subject to the borderland psychoses, the naming of fears and obsessions may be a step toward their elimination. The trouble here is found in the fact that the real nature of the obsessions is so often unrecognized by the patient. The real nature of the phobia is rarely the fear which the patient thinks it is; it is usually something more or less distantly related to that which he thinks he fears. If it is possible to find out the origin of his fear and explain the matter clearly to him, one step toward recovery is taken. If the real origin is in his own perverted metabolism, as in cases associated with auto-intoxication, the matter is easily explained to him. It is not always so easy to make him believe that this is the case, however. Constant repetition of such teaching, bringing the matter up with new lights and under the influences of increased weight, better color, etc., may help him to "name the monster" and thus destroy him.

At the same time, the ideas associated with sane thinking and wholesome habits must be called by name. The expression of the patient's plans, his fads, his wishes, his use of his health, and his ideas of his relationship with his fellows, helps him to recognize his returning health. These things do not eliminate his auto-intoxication, do not correct his bony lesions, do not feed or bathe or strengthen him in the least, but they do help him to recognize his own strength, to see his own improvement, to enjoy his own food, and to make use of the neurons which the better blood helps to returning function. Just as every doctor should teach his patients to make use of the muscles whose function is returning, as he would teach them to begin to use the broken leg as it becomes strong, so should he teach them to use the returning powers of cortical function, of better thinking and saner living.

Education of the Emotions

Work may be performed in a perfunctory manner, as a duty, with no particular coloring or interest, as a perfectly impersonal matter. Such work, if not of the most mechanical character, is not usually very well done, and if there is any opportunity for failure the work is not usually successful. On the other hand, work may be done with interest, with a desire to succeed, with faith in the ultimate outcome. Such work may fail, but if there is any chance for success it is not apt to fail. Children in school may work perfunctorily, uninterested, and simply because the work is to be done. They may learn something from such work, but if there is any chance for them to miss the real point of it all, they surely will do it. Patients may obey the instructions of the physician in this perfunctory manner, but if there is any opportunity for them to fail in grasping the point of the matter, they surely will do it.

Earnestness, and pluck, and enthusiasm, these things make for success in school life and in life's school, in health seeking and in health giving, in attainment and in transforming apparent failure into real success, and these things result from the normal relationship between the activities of the cortical centers and the ganglionar centers of the cerebrum.

Paths of Emotional Impulses

The ganglionar centers send impulses into the pontine, medullary and spinal centers, partly by way of the rubro-spinal tract and partly by way of the indirect paths which include the cerebellum. The impulses carried by the rubro-spinal tract, and probably the thalamo-spinal tract, reach both the somatic and the visceral motor centers. Thus the action of the heart, the respiratory movements, the action of the digestive and other viscera, are related to the somatic movements being governed, and the reaction is thus made the stronger and more forcible.

In the perfunctory, uninterested movements, the descending impulses seem to be carried directly to the somatic centers, and no modification of visceral activities is produced. No changes in the blood pressure or the heart's action follows, and the efficiency of the reaction is not particularly marked.

The fronto-pontal and the temporo-pontal tracts carry the impulses concerned in certain reactions, and the collaterals from the descending pyramidal cells of the motor area are sent into the red nucleus and the substantia nigra. From these centers the fibers of the rubro-spinal tract carry the impulses to the lower centers, and the resulting reaction is made efficient and strong by the associated activity of the viscera as well as of the somatic muscles.

This associated activity of the ganglionar centers and the cortical centers causes the manner of action called interested or enthusiastic or earnest.

The use of the lower centers in adding to the energy of the cortical impulses is a matter of education. The same methods which result in the development of the ability to use this force also are efficient in lessening the danger of the uncontrolled activity of the ganglionar centers.

Danger of Unbridled Emotions

Uncontrolled activity of the so-called emotional or passional states is a danger, and a very serious danger under certain circumstances. The uncontrolled emotional states act most destructively in the metabolism of the body. The child which has exhausted itself in a fit of anger is really as badly injured as if it had been sick. The grown person who loses himself in such a way is injured also, but less seriously than is the child with its developing nervous system. There is a certain danger in the fact that men are apt to imitate the emotional storms of others. Anger is contagious. The very fact of seeing another person angry, or afraid, or courageous, or laughing, causes one to begin to imitate the reactions, and soon to feel the emotion. This fact that people imitate one another, and share the expression of emotional and instinctive states, is responsible for the terrors of mob law. Any one of a number of people may be honest and just and kind, but mobs are cruel beyond expression, and corporations are notoriously unjust and mercenary. Apparently, two men are half as honest as one man, and a hundred men are honest not at all under emotional stress.

Mob Psychology

Mob psychology depends upon the imitation of the expression of any one person, and upon the fact that the inhibitions, as well as the altruistic feelings, are coördinated by neurons of higher development than are the ganglionar centers. Thus, in excitement, under the influence of the expressions of passion by others, the higher neurons are rendered non-functional, and great danger results.

Function of Education

It is the function of education to lower the liminal value of the cortical neurons, and the neuron systems which relate the ganglionar and the cortical centers, so that under conditions of excitement the cortical centers also may be active.

It is not desirable that the emotional states should be repressed. The activity of the ganglionar centers is a source of great power, and this power should be employed wisely in the ordinary reactions of life. But it must be controlled by the action of the cortical centers. Self-control is the thing to be desired, and not self-repression.

There is no difference in the ultimate quality of the emotional reactions. All are equally good, and none are essentially bad. Any emotional state may be productive of evil under certain conditions, and each has its normal place in modifying the history of the individual or the race. The feelings of enthusiasm and interest and determination have their basis in what resembles anger among the lower animals and in young children. Conservatism and hesitancy and modesty and delicacy have their basis in what resembles fear in animals and children.

The normal relationship is this, that the activity of the cortical centers, especially the anterior intermediate areas, is concerned in certain decisions relating to conduct.

These decisions, as they are being made, and as they are expressed in words more or less vividly, lower the liminal value of the neuron systems concerned in acting upon those decisions. If any one decides upon a certain course of action, the liminal value of the neuron systems concerned in that course of action is lowered, and any given stimulation is more apt to initiate that course of action than any other. By repeated decisions, and especially if these decisions are expressed in words, in detail and with exactness, the reaction decided upon becomes as probable as if the habit had been formed by repetition of the whole incident.

In school the ends to be secured are all implied in the lowering of the liminal value of the neurons of the cortical centers, and of the neuron systems which relate the cortical and the ganglionar centers in function. This is done by associating them in function through the action of the memories and associations.

Teachers, parents and physicians should realize this relationship, and should endeavor by all means to increase the relationship between the cortical activities and those of the lower centers. Always it must be kept in mind that only postponement and not prevention is the aim of the control — that expression itself is not to be prevented, but that the manner of the expression is to be subject to the effects of impulses from all parts of the nervous system, and especially from those cells in which are stored memories of past experiences and instructions.

Educational Methods

The teacher may lessen the resistance to the passage of nerve impulses between the lower and the higher centers by the use of history and poetry. Let the imagination of the child be used in the endeavor to fancy himself experiencing the emotions he reads of, let him consider how it feels to be angry, and afraid, and jealous, and ambitious. Let him, at the same time, consider the most adequate expression of these emotions, the most wise and sensible thing to be done if one felt as those heroes felt. Thus, let him also see the effects of such reactions as people are apt to make under the influence of such feelings. If there is any appearance of the ludicrous in any of the unguarded reactions, if any occurrences of the playtimes give opportunity for the display of a ludicrous aspect to unguarded display of the emotions, then these may be used. But it is not ever wise to try to show the boy or girl who is under the influence of any emotion the humorous aspect of it. Afterward, possibly, this may be done, But it is the other person's feelings and passions which are funny.

Ridicule is too sharp and cruel a weapon to use in dealing with children.

Development of Choice

Always, children should be taught to choose, and to decide, and to determine the proper reaction. Almost never should there be merely the prevention of any action, the disapproval of any action of others or the negative stand taken, without associating it immediately and emphatically with some positive and decided action which is admirable. The negative phase of existence is too often the one impressed upon children; there is too much of "don't" and too little of "do" in the home teachings, if not at school.

Now it is evident that those reactions are most apt to follow any given stimulation which have most often followed that same stimulation before. It is not really necessary that the reaction should be a concrete reply to concrete environmental conditions — if the nerve impulses concerned in any given reaction be brought vividly to consciousness, and if the chosen reaction be forced vividly into consciousness, the educational effects are practically the same as if the concrete reaction had been experienced. It is true that no determination can altogether replace actual experience in vividness and force, but the more thoroughly any one determines upon any course of action, and the more often he reviews his reasons for that action, and the good which is to result from its performance, the more apt he is to accomplish it when opportunity occurs. But if he decides upon the negative phase, if he constantly determines not to do a certain thing, and keeps this possibility present in consciousness, he is the more apt to do that which he so greatly detests. It is not good to try to conquer a fault, except as it is replaced by some other thing seen as a virtue.

Effects of Story of Cowardice

Take, for example, the effect of a story of extreme cowardice. Such a story should arouse feelings of abhorrence, and it usually does when it is told among surroundings which are pleasant and safe. Now, if the matter remains at this point, if only the feelings of abhorrence are aroused and the matter is permitted to drop out of consciousness, then at some later time there may be a similar occurrence. The person who was most disgusted at the cowardly action of the story sees his own safety to depend upon a like reaction. The action is inhibited and all of the abhorrence of the story he has heard returns, whether he remembers the details or not. Now, because of the postponement of the reaction, the longer on account of its emotional coloring, the impulses concerned in the more vivid appreciation of his danger are increased; the cowardly way of escape is seen the more vividly also, and his ultimate reaction may become the cowardly one. His fault is the more grievous and his action the more unforgivable because of the very inhibition which should have made the brave act possible.

In this case the trouble lies in the original telling and discussion of the story. The recognition of the abhorrence of the cowardly act should have been followed by a discussion and a decision concerning the more rational action; the attention of all who heard the story should have been for a time centered upon the manner of reaction which should win the approval and the commendation of all. Then, upon the occurrence of similar circumstances, the inhibition of the first cowardly impulse would be followed by the appreciation of courageous action which had been admired, and in many instances the brave action would be the one chosen.

Self Control

Because of the tendency toward the development of erratic and inefficient emotional reactions, it is needful that educational methods be directed toward the development of motor ideas together with those associated with inhibition. In securing a postponement of the discharge of motor impulses, pending the receipt in consciousness or by the lower centers of the impulses stored as memories of experiences or of associations, it is needful always to see that some efficient motor reaction be associated with every fancied or actual circumstance; that is, for example, if the student be permitted to fancy himself placed under certain circumstances in which people usually make mistakes, then he should not be permitted merely to see the mistake and determine that the reaction as usually employed is unwise, but he must be compelled to determine also, if it is possible, what other reaction should be substituted for that whose inefficiency is demonstrated. Nor must this determined reaction be held merely to include a vague and theoretical discussion of means of avoiding the contretemps, though the prevention of unfortunate conditions has a place in every discussion of them; but he must say to himself, at any rate, "What would I, thinking as I now do, consider the right, and wise, and proper reaction under such and such conditions?"

If the student's attention be directed toward the foolishness of anger with inanimate objects, for example, it is not enough for him to recognize the absurdity of this condition, but he must also be induced to see the proper reaction for conditions in which inanimate objects appear possessed of evil intentions. He should be led to see the origin of such appearances as they usually are — that is, in the weariness or the haste of the person who seems to be subject to the unpleasant combination of circumstances. Thus is he able to correct the evil, whereas if he were merely taught to inhibit the tendency to angry words or deeds, he would have no remedy at all.

Educational Therapeutics

When people have been a long time sick and in pain, their inhibitions are apt to become erratic. They are apt to hesitate and fail in exertion because of their fears and their memories of suffering. It is needful at times for a physician to take into serious account this tendency on the part of the convalescent.

In teaching them a better view of life it is not enough to try to get them to endeavor to conquer their feelings of fear and distrust; they must not be told to try to get well, as they too often say. They must be asked to decide what they will do when they do get well; they must plan for good health, not try to get it; they should attend to the pain and the feelings of unrest just enough to do the things which are needed for the relief of these conditions; then they must consider the discomfort, if they consider it at all, as something which has been attended to. It is not possible to try to forget pain, and it is not wise to force inattention to the symptoms of disease until the message of the pain has been heeded. But the chief thing in the treatment of those abnormal mental conditions which follow the excessive passage of the impulses concerned in suffering through the cells of the cerebral cortex is to cause nerve impulses concerned in altruistic feelings to stimulate the cortical neurons. Thus the liminal value of the cells of other parts of the cortex become lowered and the personality of the patient is improved. There is no easy road to this improvement either for the patient or for his nurse. It is just to take up a new and unselfish life, but in so doing he finds his own in greater abundance.

Hypochondria

Patients who suffer from the states called neurasthenic, or psychasthenic, or melancholy, or hypochondriac, or to whom other adjectives expressive of abnormal activity of the cortical neurons are applied, must be treated partly by educational methods.

The fears include a great number of the symptoms from which these people suffer. The various phobias are innumerable. These fears include the phobophobia, or fear of being afraid; claustrophobia, or the fear of being in close places; agorophobia, or the fear of open spaces; mysophobia, or the fear of contamination, and a hundred others more or less frequently seen. These fears have their basis, apparently, in some experience, but actually in the abnormal conditions of the neuron systems concerned in the consciousness and the expression of that fear.

The most important thing in dealing with cases of the types just mentioned is the correction of whatever is keeping up the faulty metabolism of the nerve cells. Auto-intoxication, starvation, fatigue, any of the peripheral irritations, and last, but not least, the almost omnipresent malpositions of vertebræ, ribs or occiput. The circulation of good blood, flowing freely with a normal pressure, is first, last and all the time of most importance in the recovery of the borderland states.

The educational treatment must be based in part upon the methods suggested in the education of children, but must be modified to suit individual requirements. The methods described in another chapter of this volume may be found helpful in this connection.

CHAPTER XIV

CERTAIN OLDER VIEWS

The older philosophers recognized the existence of mind, or soul, as altogether distinct from material or physical things. The distinction between mind and life appears, then, to be as vague as now it is in the writings of certain modern authors. The very words we use are indicative of this old vagueness. Psyche, anima, spiritus, atman, ruah, in Greek, Latin, Sanskrit and Hebrew, all mean, originally, wind, thus breath, and then life, and the chief phenomena of life, so far as individual experience goes, the consciousness. The word mind, or mynd, is of Anglo-Saxon origin, and has the significance of love, memory, or the vote. Except for the dubious uses to which the word has been put, it is of philologically excellent worth. Consciousness means the "knowing together," literally, and is fairly exact in its meaning at present.

Materialistic expressions have been used in a figurative sense in the expression of mental phenomena. Feeling, the sense of touch, has come to indicate the consciousness of emotional states. Emotion, literally a moving out or forward, is applied to the consciousness associated with the more or less involuntary reactions coördinated by the ganglionar centers of the cerebrum. Apprehension and understanding, impression and faculty, all are terms of materialistic origin, and used in the expression of conscious phenomena.

Difficulty of the Vocabulary

The rational study of the phenomena of consciousness has been hindered greatly by the misuse of the terms employed in discussions. Almost every writer of ancient times, and modern, too, for that matter, has employed old terms in distorted and grotesque meanings. Almost all of these writers have added phrases of material origin in the descriptions of the immaterial or mental life, or they have attributed the phenomena associated with the immaterial life to material objects. It thus becomes almost impossible to determine, in many cases, the exact interpretation which should be put upon the writer's views. Thus we have the spectacle, not always edifying, of pupils of the greater authors wrangling among themselves concerning the meanings of the writings of their master, and not seeking to ascertain the actual facts of the conditions.

Classifications

From the beginning there has been recognized an existence of mind as being divided into different parts. The Eleatics had a division of the mind into Sensation, Opinion and Reason. Aristotle gave a division into the Cognitive and the Motive. Much later Kant gave the division into Cognitive Faculties, Feelings (emotions) and Will.

In the physiological view, there is no need for classification of processes of mentality. Sensation is the consciousness associated with the activity of the sensory areas. Reason is the consciousness associated with the activity of the intermediate areas. Cognition is the consciousness associated with the activity of the sensory overflow areas, perhaps with a certain amount of activity of the intermediate areas. Any feeling (emotion) is the consciousness associated with the occurrence of certain somatic and visceral reactions, usually together with the sensations initiated by the exciting cause of these reactions. Will is the consciousness associated with the activity of the primary motor areas, or the motor overflow.

Body-mind Controversy

The fact that the material world could act upon the immaterial mind, and that the immaterial mind could act upon the material world, was found in very early days to present great difficulty. Empedocles laid down the maxim that like could act only upon like. Democritus supposed the mind to be composed of matter in an infinitely fine state of division. Locke refers always to the mind as perceiving the idea, and upon this he builds a fantastic philosophy, which begins with unsubstantial ideas and terminates — nowhere. The necessity for supposing a sort of "tertium quid" which could be fine enough to affect and be affected by the mind, and at the same time substantial enough to act upon and be acted upon by the material world, was considered by philosophers everywhere. This idea is constantly arising, and always in some new guise.

Kant supposed that the mind received "impressions" from the external world, and that it coördinated these impressions into knowledge.

This coördination of "impressions by the mind," as Kant and others have given it, may be supposed to be verified in the coördination of the nerve impulses by the activity of the cortical neurons. The "tertium quid" of the older philosophers may be associated with the neuronic activity, which is certainly an extremely delicate form of matter in action. Locke's mind as perceiving the idea may be referred to the fact of the isolation of the cortex, and the other fact that consciousness is associated with the activity of the cortical neurons.

Cultivation

Plato, Socrates, Aristotle and other Greek philosophers assume the existence of a soul, or mind, capable of being cultivated and trained. But the methods given for the cultivation of the soul, in so far as they are efficient, act through the effects of sensory impulses and the coördination of these. Music, the gymnasium, sculpture, letters, all are advised, and the cultivation of the sound body as a dwelling place for the sound mind is everywhere considered as the summum bonum of human culture.

Comenius, in the middle of the seventeenth century, said, "There is nothing in the understanding that was not first in the senses," and thus one of the first beginnings of a scientific study of the associative processes was made. The monumental work of Herbert Spencer laid many foundation stones for a rational study of these processes.

Volition

Spencer assumes the existence of mind as if it were apart from physiological activities, or at least as if it were able to act upon the bodily activities. He says: "The child, in learning to walk, wills the action before he walks it." This and other similar statements seem to indicate the existence of something which wills, apart from that which is controlled thereby.

According to the physiological view, the activity of the motor cortex is associated with certain phases of consciousness, which occur before the movements of the muscles affected by that activity. So the child, in learning to walk, is conscious of the initiation of the motor impulse before these impulses reach the lower centers. So he soon learns that the consciousness associated with the activity of the motor cortex is associated with impending movements. Ultimately, the consciousness of volition is associated with the activity of the primary motor cortex and the motor overflow.

Unconscious Reasoning

Wundt, who has inspired many of the modern psychiatrists, considers the impressions from environmental changes as signs, which must be interpreted by unconscious reasoning. It is evident that the supposition that reasoning is properly placed before sensation is out of harmony with the views of most psychologists, by whom sensations are supposed to make a basis for reason. But the views of Wundt are true, in a way. For what he terms "unconscious reasoning" can be referred to the activities of the cortex, and especially to the sensory overflow areas. It is probable that a certain amount of the coördination of the sensory impulses, and the associated activity of the sensory overflow areas, is essential to the consciousness of sensations. This activity of the overflow areas is the physiological expression of the condition of "unconscious reasoning."

Stated in physiological terms, this view of Wundt is, that the activity of the overflow areas is associated with vivid consciousness, and that the activity of the primary sensory areas, if associated with consciousness at all, is concerned with only feeble states of consciousness.

Mind and Life

Many recent authors define the term mind in such a manner as to include all of the phenomena of life. This definition scarcely eliminates the characteristics of crystallization from the mental state. This definition is good enough, provided it can be understood in using the term that the phenomena of life are indicated. It is rather difficult to see why any term other than life should be needed to express the significance of the word life. If by the use of this term it is intended to state that the unity of physiological processes is absolute, it has a certain value. For it seems fairly evident that what are commonly termed mental phenomena are the result of the physiological activities of the cortical neurons. The cortical neurons are simply cells, highly differentiated cells, it is true, but still simply physiological units, engaged in about the same processes of nutrition, elimination and varying activities which occupy the time of other cells.

Recent Tendencies

Two tendencies have appeared among psychologists and educators in late years. The first of these tendencies is the endeavor to compare sensations in consciousness with the nature of the variations in the external world which produce the conscious phenomena. Exact determinations have been made of the threshold limits of the different senses, the variations of the threshold limits under various normal and abnormal conditions, and the manner in which physiological phenomena have been modified by sensory impulses. Many of the laws controlling the initiation and the modification of the nerve impulses have been determined in the laboratories for the study of psychology. This work has been dignified by the name "new psychology." The names of Scripture and Titchener are associated with this movement.

The other and more recent trend was perhaps a reaction from the one just mentioned. The use of the term "subconscious" and the building of many varying and complex philosophies upon the word have occupied many pages and much nervous energy. Whatever value the use of the word may have had has been destroyed by the fact that it has been employed in a different sense by every author whose works have been consulted in preparing this volume. Yet, because the idea has been given so wide attention by physicians and educators everywhere, it seemed advisable to give a very short resumé of the use made of the expression by different authors.

Unconscious Cerebration

Carpenter first used the term "unconscious cerebration" to express the activity of the cortical neurons which are not associated with conscious changes. The term is unwieldy, but it conveys no false idea, and it has its own significance, and none other. It is certainly true that only a part of the activities of the cortical neurons is associated with variations in consciousness. Probably the activities of the cells of the external layer of the cortex are concerned in consciousness, but it is not possible to say for sure whether all of them, or whether any one of them, are associated with the conscious effects produced at any given time. There is some reason to believe that the activities of the deeper layers of the cortex act without producing any noticeable effect in consciousness, except as the activities of these cells may affect the activities of the cells of the external layer. That unconscious cerebration does occur there is no doubt.

The Sub-conscious

According to Bernard Hart the term "sub-consciousness" or "sub-conscious mind" is purely conceptual, and has no place in any experience. The term is supposed by him to be of the same nature as the terms "line" and "point" in mathematics. These expressions represent nothing existent, nothing which can possibly be subjected to experience or even imagined as existing; but the terms are used for the sake of meeting the necessities of the mathematical sciences. So he considers the expressions, atoms or molecules in chemistry, and the imponderable, frictionless ether of physicists. The term "sub-consciousness" he considers the equivalent of these expressions in the other sciences, and he considers it to be essential to the requirements of psychology as a science in order that no discontinuity of logical sequence be observed, and still no reference to physiological reactions become necessary. The crux of the whole question, from this point of view, lies in the decision as to the need for the hypothetical terminology in this case, the value of the specific term proposed, and the more crucial question as to whether the matter under consideration properly belongs in the domain of psychology or not. To take his own illustration, it is evident that lines and angles are terms of mathematics. Is it needful that some new term should be devised in order that a consideration of lines and angles should be made a part of chemistry? Or must mathematicians devise a new terminology by means of which the movements of atoms may be considered as a science apart from chemistry? The ultimate aim of every science is to bring all human knowledge to a unit; physics and chemistry, and mathematics and astronomy, must ultimately be found one and indivisible. To endeavor to dissociate by new, and abstruse, and meaningless terms, merely for the sake of the dissociation, is fruitful of nothing but endless discussion, chaotic thinking and inextricable confusion. Hart recognizes this idea and makes a very earnest plea for the maintenance of the identity of psychology as psychology, and of physiology as physiology. He deplores the endeavor of certain psychologists to explain psychical facts by physical processes. It is as unscientific to jump from psychology to physiology and from physiology to psychology in an attempt to explain mental phenomena as it would be to seek to explain other physiological phenomena by an appeal to art or letters. A lake upon a mountain top can add little of beauty to the landscape, but no one will concede that water runs down hill in order to be able to reflect the mountain. Nor is the running of water down hill to be explained upon altruistic grounds; there is no reason to infer that water runs down hill in order to irrigate the fields of the people who live in the valleys. A brook may be never so musical, yet that is not commonly held to explain the running of water. The appeal must be made directly to physics for an explanation of the fact that water does run down hill under certain circumstances, and no attempt is made by rational people to employ the terms of art, or music, or sociology in such an explanation.

Field of Psychology

It remains yet to be seen whether psychology has any legitimate field for study. If psychical facts exist apart from physiological facts, if the laws governing the activities of actual psychic entities are subject to investigation, then there is a true psychology. But no psychology is rightly named which endeavors to account for conscious phenomena in terms of the physiology of the cerebral cortex. If the physiology of the cerebral cortex can explain the phenomena of consciousness, then the study of consciousness is a legitimate part of physiology, and psychology becomes one branch of physiology — that is, the physiology of the cerebral cortex.

In order to make the matter more easily explicable, the terms employed must be as simple as is consistent with exact significances, and the same terms must be used as far as possible for the same occurrences and things in every department of science.

If this test be employed, it will at once become apparent whether there is, or is not, a need for a specific science of the mind as apart from the physiology of the cerebral cortex.

Hart's contention for the separation of physiology and psychology is a good one, but the physiologists are apt to see not very much need for a separate science of psychology, and the psychologist must be forced, as Hart has been, to devise, and adopt, and distort many expressions in many ways in order to explain psychological phenomena without the use of physiological terms.

Co-consciousness

Morton Prince, of Tuft's College, uses the term "co-consciousness" to apply to those phenomena which are within the realm of consciousness to which the attention is not directed, or of which only slight present consciousness is felt by the individual. He uses the term "awareness" in the sense in which the term consciousness is usually employed. He uses the term "consciousness" in the sense of the "reality" or the "inner life" of the brain changes. "The psychical is the reality of the physical." "I can not conceive of consciousness excepting as the reality or inner life of the brain changes."

This idea lends itself well to the physiological aspect. Consciousness may be defined as an effect produced by the activities of the cortical neurons. Prince's "co-consciousness" finds its physiological expression in the fact that many of the activities of the cortical neurons, which may not be sufficiently pronounced for the initiation of conscious phenomena, may be sufficiently stimulated by impulses from other parts of the cortex to cause the modification of consciousness.

The fact that "co-conscious" phenomena may afterward be recalled consciously is, physiologically, probably due to the fact that the neurons concerned in that particular reaction were physiologically altered by their activity so that the liminal value was lowered, then the subsequent stimulation of areas of related function might cause the initiation of sufficient activity of those neurons to affect consciousness. It is conceivable that the initial activity of the neurons concerned in the given reaction was sufficient to produce conscious phenomena, except for the presence of simultaneous inhibitions. The removal of the inhibitions is sufficient to permit the stimulation of the cortical neurons of the external layer to occur. This is probably the condition found in Prince's co-conscious phenomena.

Myers and Delbœuf, with certain other writers, assume a rather philosophical and mystical viewpoint in dealing with the subject. According to these, the sub-conscious mind is the real source of all that is good, and fine, and desirable. It is a sort of reservoir of force and wisdom. The conscious can sometimes come into relationship with this force and wisdom, and those who are so blest are seen to possess the powers associated with genius, and prophecy, and poetry, and power. The sub-conscious is thus a sort of private divinity, convenient, vague, impersonal, irresponsible and powerful.

Subjective Mind

The term "subjective mind" has been employed in about the same way. The subjective mind seems to be a conglomerate of the racial habits and instincts, together with the effects of certain disease processes. The subjective mind is supposed to be the source of all wisdom and blessedness, and the whole series of such discussions resembles greatly the philosophies of certain East Indian semi-religious writings, whereby the half-delirious imaginations associated with auto-intoxication and lack of personal cleanliness, starvation, and the assumption of the fetal position are held in reverence as the expressions of conditions higher than normal. The normal Occidental mind is not capable of appreciating these Oriental abnormalities as particularly valuable. Yet the underlying principles have attained a certain following among Occidental peoples, in connection with the supposititious sub-conscious or subjective mind.

Among Occidental psychologists, Hartmann's ideas of the sub-conscious mind show the extreme development of this concept. He considers the sub-conscious mind a universal sea of wisdom and knowledge, whose wealth is open to those who, by means of the subjugation of the sub-conscious mind, prepare themselves to employ it. "Let us not despair at having a mind so practical and so lowly, so unpoetical and so little spiritual; there is within the innermost sanctuary of each of us a marvelous something of which we are unconscious, which dreams and prays while we labor to earn our daily bread." It is not easy to see how the sub-conscious mind can be worthy of this description and at the same time be the "sum of discarded experiences" as taught by Freud.

Hudson uses the term sub-conscious mind to indicate the sum of total of nervous energies which are not associated with consciousness. It is a little obscure why he should so insist upon using the term "mind" as indicative of purely physiological nervous conditions apart from consciousness, while still employing the term mind in the sense of consciousness. The great mass of philosophy which Hudson builds depends largely upon the use of the term mind in the sense in which he defines it, part of the time, and in its commonly accepted sense at other times. That all but an extremely small proportion of nerve impulses do not affect consciousness is generally accepted. That these reactions unconsciously performed may so modify the liminal value of the neurons concerned in them as to affect consciousness at some other time appears probable. These reactions seem to be identical with the "co-conscious" activities of Morton Prince.

Ribot's Sub-conscious

Ribot speaks of "the sub-conscious," using the term in two senses: first, the static, which seems to be made up of the sum of past experiences plus inherited conditions, and, second, the dynamic, in which past experiences are constantly being rearranged and recombined with the evolution of those ideas characteristic of genius and inventions. "The sub-conscious" of Ribot is simply the sum of cortical activities which do not affect consciousness. His "static" sub-conscious is the physiological conditions of the cortical neurons. These are determined by inheritance, modified by experiences, and they are subject to variations caused by the physiological conditions of food supply, blood pressure, the removal or accumulation of wastes, the presence of poisons in the peri-cellular lymph, and so on. His "dynamic" sub-consciousness is another method of stating that the activities of many of the neuron systems which transmit and coördinate nerve impulses in the cortex do not affect consciousness. However, they may affect the cells which do affect consciousness, at the same time or as the result of later associated activities of the same or related cortical areas. This also is probably identical with the "co-conscious" reactions of Prince.

Clinical Applications

Pierre Janet, College of France, has written much concerning the phenomena of hysteria. He uses the term "sub-conscious" in the meaning of certain facts of clinical significance. The name is applied to the particular form which the personality takes in hysteria. Sub-consciousness as applied to a normal person would necessarily refer to some accident or temporary disturbance of the normal psychical processes. In other words, in the sense in which Janet uses the term, a normal person could be subject to sub-conscious activities only as a very temporary and passing disturbance, itself to be considered as a slight abnormality, only set apart from hysterical, or neurasthenic, or psychasthenic conditions by its extremely transitory condition. Janet interprets most cases of neurasthenic, psychasthenic and hysterical types to the existence of sub-conscious conditions. He treats these cases by what he calls "suggestion," which is really what may be properly termed "education." He defines suggestion as "a motor reaction brought about by language or perception." The physiological interpretation is obvious.

Baldwin uses the term "reactive consciousness" for the condition of increased susceptibility to the effects of impulses reaching the cortical areas. He considers that there can be no suggestion without consciousness.

Discarded Complexes

Freud's ideas of the sub-conscious are about as far from the ideas of Hartmann, Meyer and others of that school as anything very well can be. Freud supposes that the sub-conscious is a sort of lower level of mind, in which are stored all of the discarded experiences, arranged and rearranged into complexities of great size. This lower level he supposes to be made up of two streams or forces; one of these is seeking, or tending, to bring into consciousness those previous experiences, the cast-off complexes, which are full of mistakes and unfortunate and regrettable occurrences, while the other stream or tendency seeks to inhibit the first, and to produce in consciousness good and pleasant ideas. The second stream is thus a safety, or a guard, or an anti-toxin, if the term be permissible.

It is supposed that the production of these discarded complexes in consciousness, with associated full and complete expression of the effects initiated in consciousness, and especially in the feelings, by those experiences, relieves the conscious mind of the burden of carrying these discarded complexes, and recovery results.

The Cathartic Method

The "cathartic method" of dealing with such conditions is advocated by certain psychologists, following Freud.

Stripped of details, this method consists of securing the coöperation of the patient, then causing him to describe in great detail the incidents of his life, with especial reference to the origin of his abnormal condition. Freud's idea is that these emotional inhibitions are harmful, and that the free expression of the repressed feelings exerts a sort of "cathartic" effect upon the mind, and the cause of the disorder is removed. Freud finds in many of the borderland cases that sexual feelings, which may or may not be associated with feelings of intense disgust, have been active since childhood or early puberty, and that the psychosis may be speedily removed by the full and unimpeded expression of those ideas so long repressed.

The physiological nature of the "cathartic" method is evident. The neuron systems concerned in the inhibitory circle are subjected to a new stimulation; the circle is broken by the discharge of the efferent impulses, as in the expression of the ideas involved, and the harmful activities become inefficient. The place for discussion lies in the value of Freud's methods from the diagnostic standpoint.

In this world, especially under present conditions of silence, mock prudery and shame concerning sexual matters, it is scarcely possible for a child to reach puberty without seeing or hearing things which cause disgust or curiosity. Certainly no normal child could pass through the puberty changes, with their intense emotional storms, without being subjected to occurrences associated with at least a certain degree of shame or of exaltaion. This is the common experience. Freud's tests, then, are predestined to success, under his conditions. He explains that the ideas are to be fully expressed, that no feelings of shame or disgust shall prevent the fullest expression of the ideas, and he provides conditions which lead to a more or less complete hypnosis, or at any rate an increase of suggestibility. People who need such measures are, by that very fact, abnormal. Many of them suffer diseases which affect the sexual organs. The slight nauseas and associated digestive disturbances also give rise to ideas of a more or less disgusting nature. Thus it is no wonder that in practically all of the cases tested the method resulted in the "discovery" of the occurrences expected by Freud and those of his school. Since the treatment of such cases, as he gives it, depends upon the explanation of the significance of the results of the "catharsis," it is evident that the results may be interpreted as being due to the educational methods, or, perhaps, to the effects of the energetic suggestions.

The harm which may result from the use of such methods in certain cases is apparent. For one thing, the endeavor to produce "free" expression may be associated with increased stimulation of the centers concerned and the psychasthenic conditions made worse. This is found to be the case in some of the histories given.

The physiological interpretation of the facts as Freud states them as they are present in favorable cases is fairly simple. It will be remembered that the phenomena of inhibition are probably due to the functional activities of the circles of neurons of the different layers of the cortex, with the inverted pyramids carrying the impulses toward the cortex constantly. The lowering of the liminal value of the neuron systems concerned in producing any given inhibition causes the impulses ordinarily initiated by the daily affairs of life to stimulate them to increased activity. The variations in the physiological condition of the neuron systems primarily concerned with the "discarded complex" may be responsible for almost any kind of unbalanced neuronic activity, both conscious and unconscious.

Physiological Methods

Hugo Munsterburg, of Harvard, disapproves the use of the term altogether. He finds no reason for attributing a supposititious "mind" to those activities of the cortical neurons which are not associated with consciousness. He admits the facts of the phenomena of dissociated experiences, etc., but deplores the use of terms signifying mentality, or the psychic idea, or consciousness, for the expression of ideas which are, at the root, purely physiological. He says: "No fact of abnormal experience can of itself prove that a psychological and not a physiological explanation is needed; it is a philosophical problem which must be settled by principle before the explanation of special facts begins." In other words, if dissociated ideas have no existence in normal psychology, they are not to be lightly evoked simply for the purpose of "explaining" disease.

Munsterburg probably goes farther in the direction of a physiological interpretation of conscious phenomena than any other author of note. He has shown the effects of the emotional states upon the heart's beat, the blood pressure, involuntary muscular activity, and many other somatic conditions.

New methods for the detection of criminals based upon his work may lead to the elimination of the inhuman "third degree" and the reformation of criminals not physically incapable of reformation. The more exact diagnosis of certain diseases, and of almost any disease under certain conditions, is facilitated by the use of the methods based upon this work. Munsterburg himself uses hypontism under certain conditions in the treatment of some peculiar mental conditions, especially associated with the neurasthenic states.

This work is a beginning of a rational study of the real physiology of consciousness, and must ultimately lead to the elimination of much that is mystical, and idealistic, and fanciful in psychology.

Mental Diseases

Among psychiatrists, Wernicke has offered a new classification of mental diseases which is suggestive. He considers psychic disorders as classified according to the psychic involvement — that is, he considers certain disorders to be due to the involvement of the psychic-sensory sphere, others to the intra-psychic sphere, others to the psycho-motor sphere. This classification is based upon the study of more than five thousand cases. The classification is useful in a way, and it presents about the same relationship to ordinary methods of classification of mental diseases as the classification of physical diseases upon a basis of physical diagnosis does to the commonly accepted classification of diseases. Wernicke's classes are interesting in the study of consciousness from the physiological standpoint, since they make possible the use of the phenomena of insanity as indicative of certain psychological tendencies.

Diseases affecting the psychic-sensory sphere, then, would be associated with malfunction of the primary sensory areas, in which case sensory abnormalities, without recognizable psychic deficiency, would be found; or malfunction of the sensory overflow areas, in which case the conditions known as mind-blindness, mind-deafness, astereognosis, and such abnormalities, would be found, sometimes with and sometimes without apparent disorders of mentality.

Disorders of the intra-psychic sphere would be associated with malfunction of the intermediate areas. The disordered orientation and the lack of the so-called higher mental qualities would be associated with malfunction of either the pre-frontal areas or the parietal areas according to the conditions present.

Disturbances of the psychic-motor sphere must be associated with malfunction of the motor areas. Destructive lesions of the primary motor area are associated with paralysis, more or less localized, and not necessarily associated with any lack of mentality. Lesions involving the motor overflow must be associated with disturbances of the motor memories, motor aphasia, etc. Functional disturbances of the primary motor area may be the cause of increased or decreased motor activity, not usually properly adapted to environmental conditions. Either the increase or the decrease of the motor activities may be found affecting groups of muscles which may be strictly localized, or may be quite general in distribution.

GLOSSARY

Abstract Ideas — The ideas of qualities apart from objects of which these qualities are characteristic. For example, the idea of blueness apart from any particular thing which is blue, of courage apart from any particular person who is brave, of height apart from anything which is high, and of height in its sense of great value; all these are abstract ideas. Abstract ideas are difficult to the children of any time and to the people of the childhood of the race. Thus, the need for personifications in myths and in the ideas of young children. Physiologically, the abstract idea is the consciousness associated with that activity of the neurons of the overflow areas by means of which the elements of experiences are dissociated, and similar elements recombined. Thus it is evident that single experiences are insufficient for the formation of the abstract idea, but that for each abstraction a number of experiences having similar characteristics are essential. The lower the liminal value of the neurons of the overflow areas, the higher their functional development, the greater their power of dissociating and recombining the elements of experiences, and the greater the power of the individual to form abstractions.

Admiration (literally, to wonder at; later, to wonder at with pleasure)— The recognition of new and valuable factors in other persons or things, the sense of increasing environment. Admiration of other persons and of the deeds of others implies the recognition of valuable factors in the deeds or the characters of these persons. Admiration of grand scenery, of wonderful objects, implies a sense of increasing environment. Physiologically, admiration is the consciousness associated with the activity of the intermediate and motor areas in answer to the stimulation of neuron systems newly active, or newly related in activity, plus the occurrence of certain somatic changes, such as the long breath, the slight contractions of the large muscles, etc. Usually, admiration is associated with factors which make for the good of the race, but this is not essential. Admiration must include the slight motor activity producing the tension of the larger muscles of the body, the recognition of new factors or of known factors newly combined, and must give the consciousness of increased environment.

Affection (literally, the state of being affected) — The consciousness of an instinctive or emotional reaction to any environmental change; sometimes limited to the instinctive or emotional reaction to pleasant environmental factors.

GLOSSARY

Alexia—The loss of the power of coördinating the muscles employed in writing. Motor alexia has been found to be associated with lesions involving the foot of the second frontal gyrus of the left hemisphere.

Alternating Personality—An abnormal condition, in which the patient loses his sense of personality, then becomes conscious of himself again, but as another person. After a second shock he may recover the first personality, or he may assume another. The number of variations possible is indefinite. The variations seem to affect only his ideas of his own place in the midst of things; he usually retains his ideas of the relationships of environmental factors. He is apt to lose the functions of the more highly developed neurons, as is to be expected, since the whole affair is abnormal. These cases have not been well studied from the physiological standpoint, but the series of occurrences is probably as follows: The patient always suffers some abnormal nervous conditions, such as shock, overwork, poisoning, or some other thing capable of affecting the cortical neurons. The neurons of the left anterior intermediate area become paralyzed, probably together with certain neuron systems relating these neurons to other neurons of the cortex. Thus, the ideas of personality are lost. This appears to be associated with a loss of consciousness for a time, probably only a short time. The loss of function on the part of the neurons of the anterior intermediate area is associated with a loss of memories of things pertaining to one's self. There is usually retained all powers of language, of counting money, attending to business affairs more or less acutely, and the ordinary affairs of life, except as these are associated with personal life. The new personality is thus almost forced into lines different from the old. Later there may be other shocks, from which the new personality may be paralyzed, and the older neuron systems, having become rested, or having recovered from the first shock, may regain functional activity. The first personality may then recur. Or, the second shock may simply leave the same condition as the first, and a third personality may follow the assumption of function of new neuron groups of the anterior intermediate area. The number of times the series of events may recur is indefinite, and the number of personalities which may appear is also indefinite.

Altruism (literally, the sense of others)—(*a*) The feelings for the welfare of others; (*b*) the governing of ones' own life with regard to the best good of the race, rather than of the individual. Physiologically, altruism is: (*a*) the consciousness associated with the normal relationship between the anterior and the posterior intermediate areas, by means of which the essential unity of the race is perceived; (*b*) the control of the primary and overflow motor areas by impulses properly related from the anterior and the posterior intermediate areas, by means of which the activities of the individual are related to the conditions of the race as a whole, rather than to the condition of the individual.

Anger — The consciousness of motor reactions governed in part by ganglionar centers and in part by the motor cortex, plus the consciousness of the visceral phenomena of increased pulse, increased blood pressure, increased muscular tone, changed circulation, usually with contraction of the pilo-motors, contraction of the flexors of the hands and fingers, retraction of the lips and contraction of the muscles of the lower jaw. The environmental changes which initiated the reaction may or may not be a content of consciousness.

Antagonism (literally, to struggle against) — A sense of dislike or antipathy toward persons or things found or felt to be detrimental. Voluntary antagonism is the result of experience, and is conscious, and in part, at least, justifiable on the part of the individual. Involuntary antagonism is felt, but is not recognized as justifiable; it is usually termed "instinctive." Physiologically, voluntary antagonism is the consciousness of the activity of the primary or overflow motor areas, in answer to impulses from the sensory overflow or the intermediate areas, as these are stimulated by persons or things detrimental to the good of the individual or the race. Involuntary antagonism is the consciousness of increased respiration, increased pulse, slight nausea, slight erection of the hairs, increased tension of the mandibular muscles, and other visceral and somatic changes due to the activity of the ganglionar centers in the presence of persons or things displaying characteristics which have been found detrimental in racial experience.

Aphasia — The loss of the power of coördinating the muscles used in speech. Motor aphasia is found associated with lesions involving the foot of the third frontal gyrus of the left hemisphere; sensory aphasia is associated with lesions involving the posterior portions of the first or second temporal gyri, or to lesions involving the neuron systems relating these areas.

Apperception — The appreciation of objects or ideas in their entire significance, as they are related to all other objects or ideas, including the mind, which is thus considering them. Physiologically, apperception is the consciousness associated with the activities of the intermediate areas, both anterior and posterior, as these are affected by the activities of the sensory overflow areas. It is evident that a very nice balancing of the impulses to and from the different areas is required in order that these different activities may be coördinated; therefore apperception is a function only of neurons well developed and well related in development and function.

Attention (literally, to stretch toward) — The act of devoting the mental energies to any object or idea, either voluntarily or involuntarily. Voluntarily, attention is given to those objects or ideas which are considered valuable, apart from their power to awaken interest in themselves. Involuntary attention is that which is compelled by sensory stimulation. Voluntary attention is also called active, since it is supposed to imply a mental effort; involuntary attention is called passive, since it is not supposed to imply any mental energy.

Physiologically, attention is the increased vividness of consciousness associated with increased activity of certain areas of the cortex. This increased activity of the cortical areas is associated with descending impulses from that part of the cortex to the centers controlling the sensory organs or the motor structures in relation to the part of the cortex affected. Increased activity of the auditory area is associated with descending impulses to the posterior quadrigeminates, and the motor centers controlling the ear muscles, etc. Increased activity of the primary visual area is associated with descending impulses to the lower centers governing the eye muscles and the retina, etc. Increased activity of the primary motor cortex is associated with increased tension of the muscles receiving stimulation from that part of the cortex, and so on. Increased activity of the overflow or intermediate areas is usually associated with slight activity of the motor cortex, as is evident from the muscular contractions associated with what is called intense thought.

Voluntary attention is that due to impulses from the intermediate areas, as these stimulate any other areas of the cortex. By the action of the intermediate areas, the individual may decide to listen or to look intently, or to "pay attention" in any other manner. (See also Volition.)

Involuntary attention is that increased activity of the sensory areas due to increased sensory stimulation. Involuntary attention is most forcibly aroused by slight stimuli in the auditory areas, since the radiations of Meynert reach the stratum zonale in this region.

Autochthonous Ideas — Ideas which arise apparently without cause, and are of great force in arousing attention. Probably they are always associated with abnormal conditions of the cortical neurons, though very slightly abnormal conditions, such as fatigue or loss of sleep, may be responsible for a temporary appearance of autochthonous ideas. Physiologically, autochthonous ideas are the conscious states associated with the activity of certain neuron groups which have an abnormally low liminal value, and are thus made active in the presence of stimuli usually not efficient, such as variations in the blood pressure, the presence of slight irritants, etc., or of impulses from other parts of the cortex, not usually associated in function with the abnormal neuron systems.

Beauty, Sense of — The appreciation of that which is admirable in the esthetic sense, and afterward of abstract ideas. Physiologically, the sense of beauty depends, first, upon the activity of the overflow areas in which the primary sensations are interpreted as present, as affecting the activities of the ganglionar centers in such a manner as to increase the metabolism of the body pleasantly, and to be associated with no inhibitory impulses from other cortical areas. For example, a beautiful line is one which carries the eye along with it in curves, and which is not associated with factors detrimental to the individual or the race. The curves which are characteristic of the snake are graceful in themselves, but the associations prevent their being appreciated as beautiful by many persons. The lines of a bridge may be considered as beautiful until the fact that the structure is weak lessens the sense of beauty in those lines. Thus, the lack of inhibitory impulses from other cortical areas is essential to the sense of beauty as aroused by sensory stimuli.

Another essential factor in the sense of beauty is the lack of abruptness. Sudden variations in pitch, color, line, or a surface as felt, prevent the sense of beauty. The occurrence of the "beats" in discordant musical tones, the roughness of certain fabrics, the sense produced by passing a line of pickets through which the sun is shining, the peculiar mixtures of colors, as in cerise, magenta, etc., all are subversive to a sense of beauty, though any element of discord and even slight discomfort may be employed in the arts for the sake of contrast and for the sake of arousing the attention.

The sense of beauty as applied to abstract ideas depends upon the fact that the ideas have been found beneficial during racial, or at least family or national development. Abstract ideas essentially fine do not arouse the sense of beauty unless they have been appreciated as fine for a long time. The activity of the ganglionar centers in the control of the respiratory movements particularly seem to be concerned in the feeling of beauty, though not in the appreciation of the fact that any particular idea should be considered beautiful. Thus, it appears that the fact that any given object or idea deserves to be considered beautiful is no indication that one is able to feel its beauty. The first factor depends upon the activity of the posterior intermediate area, the second depends upon the activity of the ganglionar centers. The repeated activity of the intermediate areas in the consideration of the object as beautiful leads in time to the stimulation of the ganglionar centers by means of the neuron systems relating the cortical areas to the ganglionar centers, and the ideas or objects so considered ultimately arouse the feeling of beauty. This is the basis of the method which must be employed in education along esthetic and artistic lines.

Benevolence — The habit of giving or doing good to others. The term is usually employed in the sense of giving rather than of sharing. In benevolence there is not necessarily any idea of the unity of the race, such as is essential to altruism. Physiologically, benevolence is a characteristic of the motor activities, as these are affected from the visual and auditory overflow areas. No related activity of the anterior intermediate area is essential, nor is any activity of the ganglionar centers needful to the most perfect benevolence. Wealth may not be materially lessened by benevolence, nor may personal comfort be lessened; thus benevolence differs from altruism, which depends essentially upon the appreciation of the unity of the race, as the anterior and the posterior intermediate areas are associated in coördinated activity.

Bravery — The habit of meeting the emergencies of life with courage. Physiologically, bravery is due to the fact that the ganglionar centers are normal in structure and inheritance, and supplied with good blood flowing freely at normal pressure, and also to the fact that no excessive inhibitory impulses are being received from the cortical areas. Persons otherwise brave may become cowardly when the nutrition fails; when the fact that families depend upon their exertions increases the inhibitions; or when the memories due to a series of misfortunes initiate excessive inhibitory impulses. Bravery is the sum of the effects of the physiological condition of the body, in its nutrition, cleansing and circulation, plus the effects of the past history of the individual, plus the hereditary structure of the neuronic systems of the ganglia and the cortex.

Choice — The act of deciding between two or more conditions, ideas, or things. Choice is usually considered the act of the mind as apart from the action of the cortical neurons. Physiologically, choice is the consciousness associated with the increased activity of any neuron system, including certain cells of the stratum zonale, when the impulses from any given source overcome the impulses from other sources. The areas concerned in the coördination of the impulses associated with any subjects, between which choice must be made, receive impulses from other cortical areas in which are stored memories relating to the subjects; these memories include many of the past experiences and their interpretation; the elements of past experiences, as these have been dissociated and recombined into new complexes, by means of which the future may be anticipated; memories from the motor overflow area may add previous determinations relating to the subjects under consideration; and many other factors relative to the matter may be added to the complex streams of nerve impulses passing to and from the different cortical areas. The activity of the inhibitory neurons prevents premature stimulation of the motor cortex. Finally, some series of nerve impulses is found to attain supremacy. Perhaps impulses from the ganglionar centers exert a deciding influence, then the individual chooses because of certain "feelings"; perhaps memories, perhaps previous determinations, perhaps anticipations, perhaps fatigue of the neurons concerned in the most important considerations, determine the final choice. In any event, the consciousness associated with the increased activity of the neurons of the primary or overflow motor area is the essential feature of "choice," and this consciousness is the effect and not the cause of the choice.

Cognition — Knowing; knowledge; the state of being in consciousness. Physiologically, the function of certain neurons of the stratum zonale of the cerebral cortex.

Conception — The appreciation of anything as present and real; the act of forming concepts. Physiologically, the consciousness associated with the activity of any sensory overflow as this is stimulated by the activity of the neurons of the adjacent primary sense area.

Concept — Ideas of the qualities of things. Physiologically, the consciousness associated with the activity of the overflow areas in dissociating the elements of experiences. The concept of redness, for example, may depend upon the ideas of the similar qualities of red apples, red cloth, red roses, etc.

Conscience — The sense of doing what is right. Physiologically, the consciousness associated with the activity of the primary or overflow motor area, which is the result of impulses from the posterior and the anterior intermediate areas, with no antagonistic nerve impulses affecting the proposed or actual reaction. The existence of antagonistic impulses causes the phenomenon known as "bad" conscience, or uneasy conscience, in which there is the sense of a lack of satisfaction. In such cases the impulses from the neuron systems controlling different reactions are yet active, and the consciousness associated with this activity is the sense of uneasiness.

Consciousness — A "knowing together," a state of awareness, the knowledge one has of himself in the midst of his environment, and of himself as affected by that environment. Physiologically, consciousness is the result of the activity of certain neurons of the cortical stratum zonale. Consciousness is not localized, but the quality of consciousness at any given time depends upon the metabolism of the cortical neurons, and of their relationships in function, at that particular time. Consciousness must be considered, physiologically, as dependent upon the activity of certain cortical neurons, but not necessarily as their chief function.

Conservatism — The tendency of people or nations to continue in the same manner and customs. Conservatism is an efficient preventive of unwise reactions and of unbalanced coördinations, as well as a weight upon progress. Conservatism is to cortical reactions what habit is to somatic reactions. When nerve impulses are transmitted from one neuron group to another, always in the same manner, the liminal value of the neuron groups concerned is lowered, the tendency is for the same reactions to follow the same sensory impulses, and there is the same tendency for the neurons of the intermediate areas to follow the same stimulation when the series of impulses follow the same or related paths frequently. Thus, conservatism is the expression of habit as applied to the cortical reactions of individuals, whether they act alone or whether they are considered as units of families, or nations, or races. Since the individuals who are related usually pass through about the same experiences, the existence of a racial, or national, or family habit, or conservatism is made possible.

Courage — The condition of the neurons of the cortex and the ganglionar centers under normal conditions, by means of which environmental changes are most apt to initiate efficient replies. The consciousness of courage is that associated with the activity of cortical centers which are normal, together with the activities of the neuron groups in which memories of past successes are stored. With memories of past failures, the efficiency of the reactions of the normal person is lessened; with the memories of the most pronounced successes, the consciousness of efficiency is decreased by the activity of the cortical neurons under abnormal conditions. The lack of courage is often given as a cause of bodily inefficiency, but this is not just. The condition of the cortical neurons is the cause of the lack of courage, and this may be due to memories of failures, to poor circulation or to poor blood (thus, indirectly, to bony lesions), or to actual muscular weakness, or to the lack of certain internal secretions. The persons who display indications of lack of courage must be treated physically until blood, blood pressure, the relation of the parts of the body to one another, all are normal, and with this educational methods must be employed which lower the liminal value of the neuron systems concerned in the energetic reactions, and especially in the use of the large muscles of the body.

Crime — Any act or series of acts which are detrimental to the good of the individual or his race. Crime is the result of imperfect development of the neurons, probably chiefly of the central nervous system. Faulty neuron structure, disease conditions affecting neuron metabolism, and excessive abnormal environmental conditions, may cause criminal tendencies. Certain crimes are made probable by the existence of physical abnormalities, others depend upon environmental conditions. It must be remembered that while all functions of the nervous system are in themselves adapted to good ends, and have become so developed through ages of selection and inheritance, yet the improper relationship between the activities of the different neuron groups, between the cortical and ganglionar centers, and between the different ganglionar centers, the abnormal irritability of certain neuron groups due to excessive sensory stimulation, and the establishment of various abnormal habits, may so injure the functions of the cortical and other centers that the establishment of rational relationships between the individual and his fellows may become practically impossible. The treatment of criminals must, then, be reformatory so long as there is possibility of reformation, then protective, for the sake of persons who are normal. Punishment has no place, save as it may be considered reformatory. The tendency of modern criminologists is to eliminate punitive measures altogether, since their value in reformation seems practically nil.

Decision (literally, to cut off; hence, to put a stop to hesitancy) — The act or power of choosing, as if by volition. Physiologically, the consciousness associated with the activity of the motor overflow or the language areas, following the activity of the intermediate areas which have been accompanied by inhibitions. When the decision follows the activity of the sensory overflows, the decision is a hasty one; when it follows the activity of the intermediate areas also, especially if the inhibitions have prevented the stimulation of the motor overflow for some time, the resulting decision is well judged and fairly wise.

Delusion — Unfounded acts of judgment, by means of which persons interpret occurrences either in accordance with some fixed idea, in which case the delusions may be extremely well systematized, or without any fixed idea, in which case one faulty judgment follows another, and the words and deeds of the patient indicate a succession of unwarranted reactions. Physiologically, delusions are based upon abnormal activity of the intermediate areas, either because they are subject to abnormal conditions affecting the integrity of their metabolism, or because the neuron systems relating them to other parts of the cortex are abnormal. The common delusions of persecution, expansiveness and personal greatness are probably associated with abnormal conditions affecting the anterior intermediate area. This is known to be true in a number of cases recorded. Delusions concerning the elements of the environment apart from the personal relationships are not so common, and are found associated with lesions involving the posterior intermediate area, in some cases; in other cases no lesions relating to localized functions are to be found.

Determination (literally, to bring to an end; hence, to put an end to hesitancy or reasoning) — The act or power of deciding; the exertion of the power of choice. Physiologically, the consciousness associated with the activity of the overflow and usually also the primary motor areas in answer to the stimuli from the intermediate sensory overflow areas. Determination may also be affected by impulses ultimately derived from the ganglionar centers. While the efficiency of the determination may be due to its effect upon the motor overflow areas, the primary motor areas are usually stimulated at the same time, as is evident in the forceful gripping of the hands or the setting of jaw when urgent determinations are decided upon. The effects produced upon the motor overflow areas bring about the consciousness which is known as "making up one's mind to do" anything. These stored memories of determinations lower the liminal value of the neuron systems concerned in the reaction determined upon, and, when the circumstances favorable to the reaction occur, the reaction follows as if by habit. Determinations are very efficient both for good and for harm, and are especially urgent factors on the education of children and of the sick.

Diachesis — The lack of function on the part of a secondary center because of the destruction or paralysis of a primary center upon which the action of the secondary center depends. Thus, the area of any overflow area must be non-functional upon the destruction of the primary sense area. The motor speech center is non-functional when the auditory speech center is not functional.

Dislike — A repugnance to persons or things which are unpleasant, or repellant, or injurious. Conscious dislike is due to recognized causes; "instinctive" dislike occurs from causes which are not recognized. Physiologically, dislike is the consciousness associated with the activity of the primary or overflow motor areas (usually the primary areas) in the actions of withdrawing or antagonism in the presence of factors found harmful in the history of the individual or the race. "Instinctive" dislike, as it is called, is the consciousness of the somatic actions of avoidance or withdrawing due to olfactory stimuli, to slight and usually unrecognized visual or auditory impulses, and to the effect of these stimuli acting upon the ganglionar centers. The sensations from these bodily movements are carried to the cortex, and the consciousness of dislike is, in large part, controlled by these reactions. Dislike may be controlled by the control of these instinctive movements, and it may occur that the volitional control of these movements characteristic of dislike may be the beginning of liking, as is the case in the education of tastes.

Dominant Idea — An idea which has abnormally great place in the mental life, an idea which controls in excessive degree the judgments of the patient, and which interferes with his maintaining a normal relationship with his surroundings or his fellows. Physiologically, the dominant idea is associated with an abnormally low liminal value of certain neuron groups, by means of which two effects are produced: first, the normal activities of other areas of the cortex affect these neuron groups abnormally, and, second, the excessive activity of these neuron groups exert an undue effect upon the other cortical areas, particularly the primary and overflow motor areas, and the speech areas. This increased activity of these neuron groups still further lowers their liminal value, and they are thus still more easily stimulated. The normal brain, in which the beginnings of such a condition occurs, finds relief in rest and sleep, and the neurons involved in the abnormal process recover. Under abnormal conditions, as in neurasthenic conditions, the neurons are not permitted to recover their normal tone, and the "fixed idea" becomes an important factor in perpetuating the abnormal condition.

Dreams — States of consciousness which occur during sleep or at the time of beginning or ceasing to sleep, in which the elements of past experiences are variously recombined, with the production of complex pictures of new and often absurd types. According to Morton Prince, the relations between dreams and antecedent thoughts are direct and definite. Physiologically, this is necessarily true, provided the thoughts were known. In sleep the liminal value of the cortical neurons is raised until no ordinary stimulation is adequate. Under slightly abnormal conditions, circulatory or toxic or nutritive, the liminal value of certain neuron groups is lowered less rapidly than others. The persistent activity of those neuron groups whose liminal value remains low initiate the consciousness which would be associated with their normal activity, and thus the dream is caused. The simultaneous or successive stimulation of neuron groups which are related only because of their being affected by the circulatory conditions, as in delirium, dreams and hysteria, must give rise in consciousness to the ideas which are true in their elements, but false in the recombinations. At the instant of awaking, if certain cortical neurons are first stimulated, these affect the activities of other neuron systems related in function, and thus dreams are produced which are fairly well coördinated and rational. The activity of the intermediate areas may thus be affected, and people may "think things out" in dreams which were not well understood during the daytime. No weight can be logically placed upon the coördinations which occur during sleep or under any other abnormal conditions, but these reactions may suggest ideas which, when subjected to the effects of memories and reasoning processes, may be found of a certain value.

Duration, Idea of — The sense of the passing of time. This sense is sometimes very acute, so that persons with "the gift" are often able to tell within a few minutes the time by the clock at any hour of day or night. It may be possible for such people to awaken within a few minutes of any chosen time of day or night. This sense of exact duration is not often found, but some sense of the passing of time is usually present with normal people. The physiological basis for the sense of duration is found in the variations in the stream of consciousness, as this is affected by recurring stimuli from without, and, probably in more efficient manner, by the sensory impulses from the somatic activities, such as the pulse rate, the respirations, the visceral activities, etc., many of which do not affect consciousness directly, but which do affect indirectly the sense of the succession of occurrences, thus, as the result of education, the sense of the passing of time.

Education (literally, a "leading out," from the Socratic idea of developing the mental faculties by use and question) — The process of storing the mind with memories and of teaching the right use of memories and sensations. Physiologically, education is the process of lowering those neuron systems whose coördinated activity makes for the best good of the individual and the race. The storing of memories is the lowering of the liminal value of certain neuron groups of the overflow areas; the formation of habits, the chief factor in the education of young children, is the lowering of the liminal value of the neuron systems controlling the reactions desired; the right use of logic depends upon the normal lowering of the liminal value of the neuron systems associating the different cortical areas, thus of the intermediate areas; the development of an honest conscience depends upon the lowering of the liminal value of the neuron systems associating the motor areas with other parts of the cortex; the development of individual responsibility and of right dealing depends upon the lowering of the liminal value of the anterior intermediate area and the neuron systems which associate these areas with other cortical areas. Bad education is the unbalanced lowering of neuron systems whose activity is not so related as to make for good; there are no neuron systems whose action is essentially bad but only the incoördinated activities are bad. Educational errors are to be corrected by the lowering of the liminal value of those systems left undeveloped by the previous experiences of the individual.

Emotion (literally, a moving out; a series of reactions which occur without the control of the voluntary powers; thus, the real self is supposed to vacate the throne, so to speak, and the passions are left in control)—Emotional states are only partly subject to volitional control, especially in poorly-educated persons. Acts performed under the influence of the emotional states are stronger, more directly efficient and better adapted as replies to single environmental factors than are the acts of the type called volitional. These characteristics of the emotional states are due to the fact that such reactions are the result of the ages of inheritance and selection, by means of which certain tendencies have become perpetuated in the structure and the functional relationships of the ganglionar centers. The instincts and emotions, which are governed by these centers, are thus very efficient, very strong, and very well coördinated, in answer to single factors of environment. The emotional reactions fail in wisdom, for the very reason that they answer only one environmental demand, and include no possibility for the existence of modifying factors. The speed, strength and certainty of emotion depends upon this very lack. The value of the emotional states as these are subject to modification by the cortical areas is apparent. The consciousness of an emotion is the consciousness associated with conditions of the body, plus the environmental changes which initiate the emotional reaction, sometimes together with an associated activity of the motor cortex. In the latter case the emotion is in part of the type called voluntary, and the reaction may be either increased in force by the stimulation of the ganglionar centers, by the action of the anterior, or more rarely the posterior intermediate area, or may be lessened by the inhibitions from the same areas. These are probably carried by the fronto-pontal, the temporo-pontal or the occipito-pontal tracts.

Environment — The sum of the factors capable of affecting the body of the sensory end organs of any person or thing. The colors can not be part of the environment of the blind man, for example, though the sunshine may be, since it may make him warm, and may be a factor in adding to his health, as by destruction of bacteria, etc. The jars of loud noises may be part of the environment of the deaf person, though sounds, as such, are not. The things buried are no part of the environment of the person whom they do not in any wise affect. But these things may later become part of the environment of any person who finds and studies them. The farthest stars are part of the environment of the person who is affected by them; geological ages are part of the present environment of those people who are affected by their history. Not time and not space, but functional relationship is the test of environment.

Ethics — Those ideas of right and wrong which are derived from racial and individual experience. Physiologically, the reactions which have been found beneficial in the history of the race and the individual, in their relationships to one another, are associated with the consciousness of propriety; the sum of these reactions is called ethics, and such reactions are termed ethical.

Fear — (*a*) A series of reactions adapted to the preservation of life in the presence of danger; (*b*) the consciousness of impending danger, and of the reactions occurring in the involuntary efforts to meet that danger. Physiologically, fear is (*a*) the series of reactions occurring under the influence of the ganglionar centers in defense; these reactions include the erection of the hairs, the contraction of the peripheral blood vessels, the paralysis of certain muscle groups, etc., and (*b*) the consciousness of the somatic states as they occur, plus the consciousness aroused by the environmental factor supposed to be dangerous, plus the activities of the overflow and intermediate areas, by means of which the real significance of the environmental factors become known. Thus, fear may be increased by more exact recognition of the dangerous factors, while certain fears become lost by the recognition of the real nature of the causes of the feelings of fear. Fear is the more apt to be present if the person is unable to make adequate reply to environmental demands, as under ill health, while the well-fed, well-educated neuron systems of the cortex and the ganglionar centers are more apt to meet adverse environmental demands by the manifestations of an energetic and efficient attack.

Free Will — The power of making choice, either directly, or by choosing to attend rather to one than to another aspect of the subject under consideration. Free will has been the subject of much discussion from the metaphysical as well as the religious standpoint. The Calvinist doctrines on the one hand, and the statement of Huxley (that he would far rather be certain of always making the right reply to the demands of life than to have the most absolute freedom of will), and the teachings of certain philosophers who tinker with words in an attempt to harmonize actual freedom with a whimsical and irresponsible "will power," all display a remarkable unity of feeling, to the effect that the ultimate good is the essential thing, and that in spite of all the philosophizing and moralizing there is really a certain doubt concerning this so-called freedom. From the beginning of consciousness, the consciousness associated with the activity of the motor areas of the cortex preceded the actual muscular actions. Thus, the consciousness of the activity of these areas has given rise to the idea of causation. Since conscious states of a certain nature invariably precede the movements of the muscles, we naturally conclude that these conscious states cause the movements of the muscles. Actually, both the conscious states and the muscular movements result from the activity of the neurons of the motor cortex. The idea of a specific psychical energy arose in this manner. Its fallacy is apparent. The only lack of freedom which can interfere with the highest mental development are the self-imposed limitations in the nature of excessive inhibitions, of determinations made upon imperfect knowledge, and an excessive consideration of unimportant factors of environment.

Fringes of Consciousness — A term used by certain authors to describe the dim consciousness always present in connection with any element of vividness. For example, the most vivid consciousness of music, or of vision, or of pain, is associated with dim ideas of bodily states in general, of variations in light or sound, of the presence of other persons, of heat or cold, and of a great number of other environmental and somatic factors. These ideas, vague and sometimes scarcely recognized, are said to occupy the "fringe" of consciousness. Physiologically, since the consciousness is the result of the activity of certain neurons, and since the vividness of consciousness is the result of the energy of the metabolic processes occurring, this fringe must be the consciousness associated with relatively decreased metabolism of the neurons of the external cortical layers.

These dim conscious states are capable of affecting the cortical neurons efficiently, since memories are stored of the circumstances noted only as within the "fringe" of consciousness.

Gratitude — The feeling of good will and thankfulness following kindness or service. Physiologically, gratitude is the consciousness of the motor overflow areas as they are stimulated by the impulses from (*a*) those neuron systems concerned in the consciousness of pleasure or gain, (*b*) the neurons of the intermediate areas by means of which the source of the elements of good is recognized. Gratitude is thus in part dependent upon the normal condition and development of the intermediate areas and of their relations to the motor areas. Young children and imbeciles are incapable of gratitude in the true sense of the word, though they are capable of recognizing and seeking the sources of benefits conferred, apparently in hope of repeated favors. Gratitude is, like benevolence, a stepping stone to the development of the altruistic attitude, in which the essential unity of the race in needs, possessions and acquirements is recognized.

Habit — The tendency to perform certain acts, or to engage in certain mental processes, in a certain manner, because they have been performed in the same manner, under the same circumstances, often before. The term is properly used in the establishment of certain methods of activity, whether these are established through the nerve cells or not. Unicellular organisms seem to be subject to habits, and the cells of multicellular organisms also seem to display variations in function due to frequent repetition of environmental conditions, which is at least very much like habit, if not identical with it. In its most efficient form, however, habit is a function of neuron groups, by means of which frequent repetition of any stimulation lowers the liminal value, and thus renders those neuron groups more easily stimulated by less efficient stimuli than before. Thus, the tendency to perform any given act in a certain manner is increased each time that act is performed in that manner. Habits can not be broken directly, but they may be set aside by superseding them by other more efficient habits.

Hallucination — A sensation perceived as present, which has no basis in reality. (See Illusion.) Physiologically, hallucinations are due to abnormal conditions of the neurons of the cortical sense areas, by means of which stimuli normally inefficient may cause their activity. The stimulation of any primary sense area by abnormal conditions may give the consciousness which might be caused by such stimulation by normal environmental factors; the stimulation of the sensory overflows may give rise in consciousness to memories which are perceived as if present. The function of the overflow areas in dissociating and recombining the elements of past experiences is probably responsible for the vagaries of hallucinations. Hallucinations may also be due to disturbances of the sense organs themselves, though such disturbances are usually rationally interpreted by the patient. Certain poisons seem to have a selective action upon certain neuron groups, probably because of racial experiences, and thus they may cause hallucinations which are characteristic.

Hope — The anticipation of good things for the future. Physiologically, hope is the consciousness associated with the recombination of the dissociated elements of past experiences (including those experiences of others with whom the person may have been associated) into pleasurable complexes referred to the future. With normal pressure and nutritive conditions, there is a tendency for the normal cortical neurons to be more urgently affected by those elements of past experiences which are pleasurable. Thus, the hopeful attitude is characteristic of the normal activity of normal cortical neurons. The lack of hope, or the anticipation of evil, is indicative of abnormal conditions affecting the cortical neurons. The fallacy of the past has been that the lack of hope is a cause of bodily inefficiency. The lack of hope and the bodily inefficiency are both due to the abnormal activity of the cortical neurons, and these may be due to faulty education, but are more frequently due to fatigue, starvation or poisoning of the brain, or to abnormal pressure conditions. The normal brain in its action gives rise to the consciousness of hope.

Hypnotism is the condition of the individual in whom the cells of the stratum zonale are subject to excessive inhibitory impulses. The inhibition is produced usually by means of some methods of exhausting the neurons of a certain area. For example, the subject may be told to look at two small bright lights, placed in a rather awkward position for vision. Constantly being told to attend to the light, the visual cortical neurons become exhausted. No relationships are established with other cortical areas, and perhaps it is not illogical to say that the stream of consciousness has had a dam built across it. By the conditions of the experiment, the passage of impulses from that center to others is inhibited. The use of certain rhythmical movements has the same effect in producing the inhibition of the cells of the stratum zonale. This being accomplished, the impulses sent into the cortical centers are immediately carried to other centers without affecting consciousness at all. The overflow and intermediate areas are employed to a certain extent in some cases, but usually only the simplest coördinations are possible in hypnosis. During this period nerve impulses may be passed through those neuron groups left without the inhibitions, and the neurons so affected act afterward just as they would act if the subject had been awake and obedient to whatever instructions were given him. The injury to the cortical neurons is too great for the method to have any but the most restricted place in therapeutics.

Hypochondria (literally, beyond the rib cartilages, from the old idea of the place of the liver in causing the sumptom) — A form of melancholia in which the symptoms of terrible diseases are fancied by the patient. The condition is due, first, to any of the causes of melancholia, and the peculiarity is due to a lowered liminal value of the neuron systems concerned in transmitting the sensations of pain and discomfort. Delusions of impending death and disaster may be the result of disordered function of the intermediate areas. Circulatory disturbances are always present; the blood pressure is usually very high, but may be abnormally low.

Hysteria—This is usually defined according to Möbius as "a state in which ideas affect the body and produce morbid changes in its functions." It is characterized by excessive suggestiveness or ideoplasty, and by various disorders of consciousness. From the physiological aspect, hysteria appears a disease of the neurons of the stratum zonale, and probably of certain of the deeper layers of the cortex, by means of which their normal activity is either lessened or increased. The phenomenon of hysteria could be produced by a localized constriction of the cerebral vessels, but at present the possibility of such local interference with the cerebral circulation is not known. It must be remembered that ideas are the result of the activity of the cortical neurons, that the injury to the bodily functions also is the result of the abnormal activity of the cortical neurons, but the ideas themselves do not cause either disease or recovery. The treatment of hysteria must be based upon the establishment of normal nutritive conditions for the cortex, and upon the educational development of the cortical neuron systems.

Idea—A term used in several different meanings. It is properly applied to the thought of anything not present, so far as sensory stimulation is concerned; a memory related to other memories. An effort has been made to apply the term "idea" to psychical facts which are without physiological basis. Since no psychical facts without physiological basis have been recognized, the value of the proposed use of the word is not evident. Physiologically, an idea is the consciousness due to the activity of the overflow areas in relating any memory to other memories.

Idea of Reference—A fixed idea of personality; the tendency to refer all environmental variations to personal conditions. The condition is found in patients with delusions of expansiveness and persecution, and in certain hysterical and neurasthenic states. They hear their own names in the distant voices of strangers talking; they fancy that strangers are always noticing and talking about them, and they refer the most distant political events to themselves. Physiologically, the condition is probably due to an abnormally low liminal value of the anterior intermediate area (of the left hemisphere), so that the activities of the other cortical areas, especially the primary sense areas, affect the abnormal area in excessive degree and in an incoördinated manner. (See Dominant Idea.)

Ideation—The act or process of thinking; the process of successive adjustments of the activities of the primary and overflow sensory areas with the activities of the intermediate areas.

GLOSSARY

Ideoplasty—A term employed by Ochorowicz to express a condition of increased suggestibility. The term refers to the condition in which the thought alone of any functional modification determines such functional modification; for example, the thought of yawning itself produces yawning. The condition is present in an abnormal degree in hysteria, and in certain of the insanities in which echoing and imitation are present. The condition is present in children as they are just going to sleep, and to a less extent in grown people under the same condition. Physiologically, ideoplasty refers to a condition of lowered liminal value of certain neuron groups, so that the stimuli ordinarily inefficient may initiate their activity. When the lack of sleep is present, the neuron systems controlling yawning have a lower liminal value, and the thought of yawning causes the reaction to occur, even in the face of the most urgent inhibitory volitions.

Identity—The sense of identity may refer either to the identity of one's self or to the identity of things perceived. The sense of one's own identity is that idea which normal people have of being the same person through life; the idea of immortality is associated with the sense of the impossibility of there being any cessation of identity. Nothing can be said or thought, under normal conditions, which can make the possibility of failure of the sense of identity thinkable. Abnormally, changes in the sense of identity are found. (See Alternating Personality.) The sense of personal identity is due, physiologically, to the fact of an unbroken series of neuronic events occurring in the anterior intermediate area, probably of the left hemisphere.

The sense of the identity of external objects is due, physiologically, to the activity of the primary and overflow areas, by means of which memories and primary sensations are compared, point and by point, and found to agree perfectly in the essentials. The activity of the intermediate areas may be concerned in the decisions concerning identity in doubtful cases. The sense of the identity of persons or things with the memories of persons or things, when a long time has elapsed between the storing of the memory and the appearance of the persons or things; and the recognition of the identity of things with their reflection as seen in a mirror, are due to complex activities of the primary, overflow and intermediate areas.

Illusions—False ideas caused by abnormal interpretations of sensations, due to conditions actually present. For example, a waving line may be seen as a snake, dots may be seen as moving animals, slight noises may be heard as voices, food tasted as poison, and so on. Illusions differ from hallucinations in being based upon actual sensations, whereas hallucinations are not based upon any sensory impulses whatever. It is not always possible to say whether any given false ideas have as their basis an actual sensory impulse or not, since there seems to be no limit to the distortions which the abnormal cortex may impose upon the nerve impulses reaching it. Physiologically, illusions are due to abnormal conditions of the sensory overflow areas, by means of which the primary sensations are improperly coördinated. The false ideas in consciousness are due to the unwarranted activity of the abnormal neurons.

Images — The ideas aroused of external objects or of somatic conditions by attention or thought. Physiologically, images are the conscious states produced by the activity of the sensory or motor overflow areas.

Imagination — The power of conceiving things which are not, and perhaps never can be, present in fact. Physiologically, imagination is the consciousness associated with the activity of the overflow areas, as these dissociate and recombine elements of past experiences. The term is also applied to the consciousness associated with the activity of the intermediate areas, as the elements of past experiences, dissociated and recombined to a certain extent in the overflow areas, are still further associated with other elements in the building of more complex structures of thought. Children and persons of undeveloped mentality are often unable to recognize the difference between the images due to the recombination of the dissociated elements of past experiences and the memories of the experiences themselves. The "lies" for which children are punished are often these images so produced, and repeated by the child in good faith as being actual experiences. The increasing development of the overflow areas and the development of the posterior intermediate area lead to the power of recognition of the absurdities of the imagined experiences, and the power of realizing the differences between the imagined experience and the actual one.

Imitation — The tendency to perform acts in the same way in which they are performed by others. Physiologically, imitation is due to the fact that, in the absence of inhibitions, the stimulation of the sensory and intermediate areas by any movement is apt to initiate the stimulation of corresponding motor areas. For example, if a child sees any person smile, the stimulation of the cortical neurons concerned in vision stimulates the cortical neurons concerned in the motor reaction of smiling, and, unless there is some cause for inhibiting impulses acting upon the motor neurons, the child smiles back. The lack of the inhibitions in young children and in the feeble-minded, and in certain insanities, is shown in the tendencies of these to unmodified imitation.

Instinct — The faculty of performing certain complex acts without training, experience, or anticipation of the results of the act. Instinctive acts are performed under the control of neuron systems which are, because of hereditary structural relationships, adapted to carrying the impulses from certain sensations to certain motor neurons. The instincts are merely more complex reflex actions, and may be modified, inhibited or superseded by habits. Instinctive acts are capable of becoming fixed by repetition or of being eliminated by the frequent occurrence of habitual acts of different or antagonistic characteristics.

Intellect, Intelligence — These terms are used in slightly different senses by different authors. The older idea of the classification of the mental faculties into "intellect, emotions and will power" indicates the manner in which the terms have been employed. Intellect is sometimes limited to the power of perceiving relationships between things which have no personal bearing, while intelligence is sometimes used in the broader sense of the ability to perceive, especially to perceive clearly. Both words display a number of delicate nuances in the literature of psychology. The physiological interpretation of the term depends upon its use; intellect as it is used in the sense of the power to comprehend clearly the relation of things apart from their personal bearing refers to the perfection of development of the posterior intermediate areas; intelligence, in the sense of the power to understand clearly the factors of environment, depends upon the perfection of the development of the overflow areas. The terms are usually employed in such a manner as to eliminate the consciousness associated with the activity of the ganglionar centers and of the motor areas from their meanings.

Interest — The quality of consciousness associated with those sensations or actions which have an emotional coloring; things as they are perceived or actions as they are performed which have a personal bearing. Physiologically, the consciousness associated with the activity of the primary or the overflow areas together with the activity of the anterior association area. Personal interest, or selfish interest, is associated with the activity of the anterior intermediate area only; impersonal, or altruistic, or scholastic, or academic interest is based upon the activity of the posterior intermediate area also. The sense of a voluntary compelling of interest is due to the activity of the posterior or the anterior intermediate areas as impulses are sent to the motor areas; by means of this action the muscles are slightly contracted, the blood pressure raised, the liminal value of all cortical neurons is lowered, and thus the transmission of impulses from one area of the cortex to another is facilitated. The activity of the motor neurons causes the consciousness of volitional effort. (See also Attention and Choice.)

Introspection — The process of attending to one's own mental processes and feelings. Physiologically, the consciousness associated with the activity of the anterior intermediate areas, together with related activity of the posterior intermediate areas, but without any marked activity of the sensory areas, either primary or overflow.

Invention — The act or power of recombining the elements of past experiences into new complexes which may or may not affect the activity of the motor areas. The term is usually employed in the sense of the formation of new complexes which are useful, and the recognition of the usefulness of an invention depends upon the activity of the posterior intermediate area. The remarkable inventiveness of certain insane persons, by whom the most intricate and absurd machines are devised and manufactured, depends upon the increased activity of the overflow areas in the recombining of elements, without the coördinating activity of the intermediate areas, by which the value or the worthlessness of the devices could be determined.

Joy — The sensations caused by the recognition of great good, either to the individual or to the race. Joy differs from pleasure in that repetition is not an essential factor in joy. Physiologically, joy is the consciousness associated with the activity of the neurons, chiefly of the intermediate areas, in which the elements of past experiences have been recombined so as to bring about such a new grouping of these elements as to lead to motor activities which are of great good to the race in the future. The non-physical factor in joy is shown in the joy which may be associated with great sacrifice, and with the most urgent suffering. The motor factor in joy is not essential, since joy may be associated with impending good, from which the individual is debarred; but his joy lies in the fact that he is identified in consciousness with the other members of his race.

Judgment — The statement of a decision or the performance of an act resulting from reasoning. Physiologically, judgment is the consciousness associated with the activity of the motor or language areas caused by the activity of the intermediate areas, especially the posterior intermediate area. Judgments are proper and just in the measure in which (*a*) impulses from the overflow areas are permitted to affect the activity of the intermediate area, and (*b*) impulses from the anterior intermediate area and the ganglionar centers are not permitted to affect the activity of the posterior intermediate area. Thus, judgments are not properly modified by personal, or emotional, or instinctive factors.

Language — The act or power of expressing thought by means of the voice, the movements of the hands in writing, or the movements of the body in gestures. Physiologically, language is a function of certain neuron systems by means of which the dissociated factors of past experiences may serve as efficient stimuli for dissociated motor experiences. The transmission of dissociated sensory elements into dissociated motor elements without the formation of the complexes of actual experiences facilitates the activities of the intermediate areas in much the same way as the establishment of habitual reactions facilitates the activity of the cortical areas. The stimulation of the motor areas causes the movements of the body, with the formation of gesticulations, vocal or written language, or the use of the various symbols, and thus the different individuals of any family or race are enabled to share their experiences, and also the judgments, etc., based upon the dissociations, recombinations and coördinations of these experiences.

GLOSSARY

Since the language centers are so closely associated with all the overflow and intermediate areas, the place of the activity of the language centers in coördinating the impulses transmitted by way of these centers is an important one. Thus it is evident that the more exact and clear the use of words is made, the more exact and clear the consciousness associated with language, and the more exact and just the decisions based upon the activity of the cortex in general.

Mania — A symptom complex characterized by several phenomena; the excessive activity of the smaller neurons of the motor cortex is associated with great restlessness of the smaller muscle groups of the body and an increased tension of the larger muscle groups; the body movements are modified by these reactions; the liminal value of the cortical neurons is decreased abnormally, and the inhibitions appear to be decreased, though this is not subject to proof; the consciousness is that associated with increased activity of the cortical neurons, and is that of well being, a rapid flow of pleasurable ideas, and much joy in living.

Melancholia (literally, "black bile," in reference to the supposed place of the liver in etiology) — A symptom complex characterized by several phenomena; the partial paralysis of the larger pyramidal cells of the cortex is associated with a partial paralysis of the larger muscles of the body; the body posture is characterized by this weakness of the large muscles; the liminal value of the cortical neurons is abnormally increased throughout, so that stimuli which are efficient in arousing motor reaction under normal conditions fail to arouse any reaction in the melancholiac person; the consciousness is that associated with the activity of the starved, half-paralyzed and inefficient neurons of the cortex.

Memory — The reproduction in consciousness of past mental states. The physiological basis of memory lies in the fact that the stimulation of any neuron or neuron system lowers its liminal value, and thus renders it more susceptible to subsequent stimulation. Thus, those neurons or neuron systems affected by any experience are easily stimulated by the recurrence of the same or similar circumstances afterward. The memories are to the neurons of the stratum zonale what the habits are to the nerve centers in general. Memories are stored in the neurons of the overflow areas chiefly, if not entirely. Memories of motor experiences are stored in the motor overflow. The motor overflow may be stimulated by the other areas of the cortex, and the effect of this stimulation may affect the future reactions of the motor overflow cells, and thus the cells of the primary motor area. Thus, determinations are to the primary motor area what the memories are to the primary sensory areas, except for the reversal of the time relationships. A determination is, so to speak, a memory made before-hand. Memories which are not present in consciousness are not actually existent anywhere, but the physiological condition of certain neurons is such that they may be stimulated easily. The variations in the physiological conditions of the neurons or neuron systems concerned is the only manner in which memories can be supposed to be "stored." The consciousness of memories is the consciousness associated with the activity of the overflow areas.

Mind (from an Anglo-Saxon word meaning originally either love, or memory, or a vote)—The sum of the conscious states; as distinguished from intelligence, which is usually limited to the mental faculties, exclusive of the emotions or the volitions. The term originally is a good one, with exact meaning, but certain later authors have applied it to those reactions which appear to indicate any choice, or the power of making adequate reply to environmental changes; the word is even applied to the factors which determine the combinations of atoms or the actions of gravity or magnetism. In its original sense mind is, physiologically, the consciousness associated with the sum of the activities of the cerebral cortex.

Neurasthenia (literally, nerve weakness) — A disease of the nervous system, in which the nerve cells display excessive irritability, and at the same time excessive liability to fatigue. The picture of neuron metabolism is like a very much exaggerated fatigue. The abnormal states of consciousness are due to the abnormal neuron activity, and these affect the body in various ways. The lowered liminal value of the cortical neurons leads to excessive activity of the motor cortex, and thus to overwork. Thus, it appears that overwork may be an early symptom of neurasthenia, rather than its cause, though the overwork is often the real cause of the disease, and is certainly a very efficient factor in perpetuating the condition. Recovery must depend primarily upon the removal of all irritating conditions, the establishment of normal blood flowing freely under normal pressure, and such educational methods as may be indicated in the individual case.

Orientation (literally, a turning) — The act of relating one's self to one's environment; the sense of making adequate reply to environmental variations and thus of being properly placed in the midst of things. Disorders of orientation may result from the fact that adequate reply to environmental demands is impossible, or to an abnormal condition of certain neuron systems concerned in controlling the motor actions, or in affecting consciousness. Physiologically, the act of orientation depends upon the activity of the neuron systems relating the sensory to the motor areas. The consciousness of being properly orientated depends upon the normal activity of these neuron systems, plus the normal activity of the intermediate areas, by means of which the significance of the environmental variations and the significance of the replies made by the individual are perceived.

GLOSSARY

Pain — The uncomfortable sensation which results from the injury of the body, either from conditions within itself, as in disease, or from external agencies, as by pricking, etc. The sense of pain from environmental losses, as in the loss of friends, disappointments, etc., may be included in this sense, and the pain in such cases is referred to the body itself. The cortical localization of pain is not known, though there is some evidence in favor of an area for the appreciation of pain in the post-central gyrus and the adjacent cortex.

Perception (literally, seeing through) — The act or power of associating sensations with other sensations and memories, with an appreciation of the significance of the thing perceived. Physiologically, perception is the consciousness associated with the activities of the overflow areas.

Phobia — A fear or horror, usually found in neurasthenic or psychasthenic patients, usually associated with certain objects, which are characteristic of the patient, but are not alike for different patients. Phobias are probably remnants of racial experiences, and they recur in force under abnormal conditions which lower the liminal value of the neuron systems concerned in the expressions of fear and horror to such a degree that the slightest stimulation of any sensory organ is sufficient to initiate the whole reaction. The pulse, respiratory and blood pressure changes, the contraction of the pilo-motors, the trembling of certain muscles and the inhibition of others, all occur as if efficient causes of fear were actually present. Efforts at self-control only increase the somatic phenomena, and thus increase the feeling of fear. The physiological basis of the phobias is found in the presence of some abnormal condition which greatly lowers the liminal value of certain neuron systems of the ganglionar centers. Recovery must depend upon the removal of the abnormal conditions underlying this irritation, and upon the establishment of good circulation of good blood through the cortex as well as the ganglia. The liminal value of the cortical neurons, especially those of the posterior intermediate and the overflow areas, must be lowered by educational methods.

Pleasure — The sensation due to occurrences found beneficial either to the individual or his race, during the history of the race. Physiologically, the consciousness associated with the activities of the cortical areas which have often recurred in the history of the race, and which are apt to recur again. It is the fact of the recurrence which gives the sensation of pleasure in consciousness, and not the pleasure which causes the recurrence. Pleasure of the most intense sort may be associated with the most intense pain, and the fact of impending injury or death is not always sufficient to inhibit pleasure; but the fact that certain circumstances have constantly and invariably recurred during racial history is the chief factor in pleasure.

Psychasthenia — A form of neurasthenia in which the neurons of the cortex are most seriously affected. The patient who suffers in this way is apt to find himself unable to study, to think, or to remember with his accustomed ease, and the least endeavor to perform his ordinary mental tasks is almost immediately followed by overpowering fatigue. The lowered liminal value of the cortical neurons in psychasthenia may cause very vivid imaginative processes, and many brilliant successes in literature have been based upon slightly abnormal conditions affecting the cortical neurons in this way. No right judgments can be based upon abnormal cortical activity. Recovery must depend upon the establishment of normal nutritive and circulatory conditions of the body, rest for the affected neurons, and increased activity of any neuron systems which may have been left undeveloped by the personal habits of the patient. The removal of poisons, either stimulants or those of autogenic origin, from the blood is of first importance in such cases.

Reasoning — The act or power of associating ideas in such a manner as to result in a judgment. Physiologically, reasoning is the process of the coördination of the nerve impulses arising from the activity of the primary and overflow areas by neurons of the intermediate areas. The inhibitory impulses are concerned in delaying the stimulation of the ultimate reaction until opportunity is permitted for many impulses from many overflow areas to reach the intermediate area. These streams of nerve impulses finally are coördinated in such a manner that nerve impulses are sent to the speech centers, and the decision is voiced, or written, or expressed in other ways; or to the primary motor area, when the decision is followed by appropriate action; or to the motor overflow area, in which case the decision is saved until future circumstances permit the stimulation of the neurons affected, and the reaction decided upon is performed. The series of neuronic events just mentioned may occur without affecting consciousness, and the motor reactions occur under such circumstances as if they were instinctive and not judged. The term "reasoning" is usually limited to those processes which occur consciously, but there is no essential difference in the methods by which the ultimate reaction is determined, whether consciousness is associated with the neuronic activity or not. Consciousness does not in any way control reasoning, but is usually associated with the activity of the intermediate areas, especially when many nerve impulses are being coördinated — that is, when the matter is of importance.

Recognition — The act or power of knowing again, of perceiving the identity of any experience or memory with other experiences or memories. Physiologically, recognition is based upon the simultaneous or consecutive activity of different neuron groups, their comparison, and the fact that the impulses are identical. Sensations may be compared with memories, memories with other memories, and the complexes produced by the recombination of the dissociated elements of past experiences may be compared with memories or with sensations, and recognition may follow.

Self — The sum of personality, the sum of the activities of the neurons of the anterior intermediate area, as these are affected, and have been affected, by sensory impulses from the body itself, from its entire environment, and from the intermediate and overflow areas. The term should be limited to the consciousness of body, and should not be applied to the body apart from the effect in consciousness. The disease which causes conscious pain or discomfort is a part of the self; the disease which bides its time in darkness is not a part of one's self. The self is not diminished in the loss of an arm, save as this loss diminishes power and the consciousness of power. The person who loses his limbs and who retains his consciousness of power, by means of employing his other members with greater facility, has lost nothing of himself; but the other person whose physical weaknesses are associated with a loss of conscious power has lost part of himself.

Sensation — A feeling, the effect upon the mind of something "sent" in from the external world. Physiologically, the term is used in two senses: (*a*) the effect of external variations upon the sensory neurons of the first order, (*b*) the consciousness associated with the activity of the primary sense areas of the cortex. Commonly, the term is also applied to the consciousness associated with the activity of the overflow areas, as in the less complex coördinations. Thus, it is said that we see that anything is of a certain size or distance. The activity of the visual overflow area is concerned in the appreciation of size, distance, solidity, etc., and the primary sensations of vision are only of a flat colored surface. The activity of the auditory area is associated with the consciousness of sound, and the activity of the auditory overflow is concerned in the hearing of words in their significance, etc. The activity of the other primary areas is associated with the consciousness of the specific function of those areas.

Shame — The sense of having appeared, or spoken, or acted in an unbecoming manner. Physiologically, the consciousness caused by the activity of the neurons of the anterior intermediate area as these are stimulated by impulses from the primary and overflow motor areas, together with inhibitory impulses from other cortical areas. Thus, the constant sense of "wishing I had not done it," which is so essential an element of shame.

Soul — A term which has been used in many different senses. It is usually employed to signify the mind, or the intelligence, or the will power, or the sum of the emotions, or the transcendental part of personality, which dwells apart from neuronic activity, and which is not very intimately associated with the body. The term has fallen into disuse because it has been used in so many meanings that its value is lost, unless care is taken to explain in which significance it is being employed.

Space, Idea of — The idea of space is the consciousness associated with the activity of the areas intermediate between the visual, auditory, somesthetic, and perhaps the muscle sense overflows. Thus, the consciousness associated with the activities of each of these areas is concerned in the appreciation of space as an abstract idea.

Stream of Consciousness — The constant series of varying states of activity of the neurons of external layers of the cerebral cortex, and of their effects. The term "stream" refers to the fact that this series of physiological variations is never, under normal conditions, interrupted.

Sub-consciousness — A term used in different senses by different authors. It has no place in the physiology of consciousness, but the varying meanings which are attributed to the term may be defined in physiological terms. (See Chapter XIV.)

Subjective Mind — A term which has been variously employed by different authors as describing certain physiological activities not associated with consciousness. Its significance varies from the forces which govern the universe and control the evolution of living creatures down to the neuron activities concerned in reflex actions and in instincts, and to the phenomena of the lives of unicellular organisms. The term has no logical place in physiology or psychology.

Thought — (*a*) The act of considering; (*b*) the ideas subject to consideration, usually without personal bearing. Physiologically, thought is the consciousness associated with the activity of the intermediate areas — the posterior, if the thought is impersonal — in which the impulses from the sensory overflows and from other cortical areas are sent to and from various neuron groups. The inhibitory impulses form an important part of the series of neuron activities concerned in thought. Thought differs from reason in the fact that the decision may be greatly delayed in thought, while in reason the whole series of neuronic action tends to the decision. The complexity of thought and the justice and wisdom of the resulting volitions or determinations depend upon the number of the sources of the original stimuli. The vividness of thought and the force of the resulting volitions and determinations depend upon the vividness of the memories and sensory impulses which enter into the series of reactions. As in all coördinations, the vividness and the efficiency of any series of reactions depend primarily upon the physiological conditions of the neurons concerned in the reactions.

Transcendental Self, or Ego — A personality apart from neuronic activity, concerning whose existence there is no physiological evidence, but whose non-existence is unthinkable to the normal mind.

Volition — The act or process of choosing or determining; the will. Physiologically, volition is the consciousness associated with the activity of the motor areas, as these are stimulated by the activity of other parts of the cortex.

Will—(*a*) The act or power of choosing, the expression of a determination; (*b*) that which is chosen or determined upon. Physiologically, will is the consciousness associated with the activity of the primary or overflow motor area of the cortex. Will is not the exertion of any psychic power; it is the consciousness produced by the activity of the motor areas. Since this consciousness has invariably been followed by the contraction of muscles, the effect of actual volition is produced; in other words, the fallacy, "post hoc, propter hoc," has hidden the real relationship of cause and effect. (See also Choice and Determination.)

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Baldwin, Cattell, Clevenger, James, Marshall, Scripture, Thorndyke, Kræpelin, Ziehen, Wernicke, Meyer, Morel, Kahlbaum, Schule, Arndt, Wundt, Kraft-Ebing, Neumann, Freud, Lowenfeld.

The Nervous System

Apathy, Auerbach, Babinski, Baillarger, Bechterew, Bethe, Betz, Broca, Burdach, Butschli, Cajal, Charcot, Ciaglinski, Clarke, Dejerine, Ehrlich, Flechsig, Gowers, Head, Helmholtz, Hertwig, His, Kolliker, Key, Langley, Lissauer, Loewenthal, Mallory, Mandel, Mobius, von Monakow, Munk, Nägle, Nansen, Nissl, Pfluger, Purkinje, Ranvier, Remak, Sabin (Florence), Sherrington, Stannius, Turck, Waldeyer, Weigert, Wright.