STUDIES IN THE OSTEOPATHIC SCIENCES

BASIC PRINCIPLES

VOLUME I

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PREFACE TO THE SERIES.

This series of text books is to be composed of eight volumes, dealing with the sciences which must underlie a rational system of therapeutics.

The appearance of the series may be modified by the publication of books dealing with the same subjects by other authors. For this reason, it is considered unwise to offer an exact list of the volumes in order. They will, however, consider the etiology, nature, prevention and diagnosis of diseased conditions, and the best manner of dealing with sick people from several standpoints.

It is intended that laboratory methods of investigating these subjects shall be magnified. The time is past for endeavoring to settle matters of fact by an appeal to argument, even though the argument be logically based upon premises from the best of authorities. Original work will hold first place in these books. It is not intended that the researches of others shall be disregarded. The only point is that it is actual observations which are to be considered, and not arguments based merely upon other people's opinions.

It is evident that such a work as this must require much time. Therefore succeeding volumes are not to be expected at short intervals.

LOUISA BURNS.

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PREFACE TO THE FIRST VOLUME.

This book is written for the use of students of osteopathy, either before or after their graduation. It is hoped that the rather broad discussion of the biological principles upon which the methods of osteopathic therapeutics are based will be found somewhat suggestive and convincing. The experiments demonstrating the osteopathic centers are described rather fully, in the hope that they may be repeated or continued by others.

The collateral readings at the foot of the chapters will be found instructive. It is expected that students who take up this book have already a fair knowledge of biology, anatomy and physiology, both comparative and human. The collateral readings will include, however, references to those text books of physiology which contain especially valuable discussions of points referred to in the different chapters. For those who wish to study the collateral subjects more thoroughly, the bibliography will be found helpful, though it is by no means exhaustive.

The glossary has been generously planned. The needs of those students of osteopathy whose diplomas are beginning to turn yellow were especially considered in the preparation of this feature.

Wherever this book may go, I wish to send with it my earnest appreciation of the tireless and intelligent assistance which the students of The Pacific College have given me in its preparation. During these long series of experiments, amid the difficulties which always attend new work, I have found continued inspiration and strength in the enthusiastic co-operation of my friends, my fellow-students in the Laboratory of Physiology.

The kindly interest of my fellow teachers and of the osteopaths of the County Association has been very helpful.

I should like this book to carry with it also my sincere gratitude for the generous encouragement and the thoughtful advice given me by Clement A. Whiting, D. Sc., D. O.

LOUISA BURNS.

The Laboratory of Physiology,
The Pacific College of Osteopathy,
Los Angeles, California, July 3, 1907.

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DR. ANDREW TAYLOR STILL.

In 1874, Dr. Still began the study of the science now known as Osteopathy. The idea of viewing the human body as a machine, planned by a Master Mechanic, "thoroughly furnished to every good work," is the foundation of Dr. Still's early teachings. The urgent need of careful and exact diagnosis, and the essential importance of the study of the structure and function of the normal body, are impressed again and again upon the reader of the books written by Dr. Still. Many of the precepts found in his writings are used in daily practice by thousands of osteopaths all over the country. We who live today can have no adequate conception of the magnitude of the changes in therapeutic ideas which are being brought about through the teachings of Dr. Still and his followers. The future generations will know, perhaps, but people of his own day can never know the measure of the influence of that great man toward right and wholesome, free and temperate living.

CHAPTER I.

NORMAL STRUCTURE IS ESSENTIAL TO NORMAL FUNCTION.

While this statement is true, in the long run, it seems observed more often in the exception than in the rule. The most conspicuous deformities are associated with apparently normal functions, and slight or gross mal-positions are sometimes a long time present without attracting any attention, or any apparent interference with the functions of any part of the body. It is the place of this chapter to discuss the significance of this rule, and its exceptions, both real and apparent.

Normal Structure and Normal Function.

The word "normal" literally means "according to rule," and this original significance still underlies its later usage. In this connection, the "normal structure" is that which is the rule among living things, and "normal function" is that which is according to the rule of these same living creatures. The rule, in all living things, is the maintenance of the longest, strongest, and most productive life possible to its kind.

The structure which makes possible the longest and most productive life is the normal structure, and the mode of activity which is maintained by the longest and most productive life, is the normal function. Both of these conditions are the result of many centuries of progressive reactions to changing environments.

In the time during which life as we now know it has existed in the world, all living things have been affected by the changes in the seasons, in their food, and in their neighbors. The manner of the reply which living things make to these environal changes is the test of their right to continued existence. Thus, they have adapted themselves to the present condition of life by both structural and functional changes. That structure which is best adapted to the conditions of the environment of any organism is the structure which is normal to that organism, and that manner of living which enables an organism to derive the most energy from its environment is the function normal to that organism. Thus, both function and structure, considered in the biological sense, are what the mathematician would call "functions" of the relation between the environment and the inheritance of the organism.

Under ordinary conditions, the structure of any organism is the result of the sum of its inheritance through all its phylogenetic history, as modified by its ontogenetic history. If this sum of traits is such as to facilitate its powers of deriving energy from its environment, and its powers of making a strong and rational reply to environal changes, it lives a normal existence.

Under unusual conditions, the structure of any cell or organism may become abnormal. It is then unable to derive the energy from its environment which is required for its normal metabolism. Its function is then also abnormal.

The Structure of the Biogen.

If that common and mysterious thing, the molecule of living proteid, be thought of as a machine, it is very evident that the normal relations of all its parts are essential to the maintenance of its normal activities. The living proteid molecule is very like a machine, as far as we now know it. The very simplest of living molecules are very complex, compared with inorganic molecules, and there are unquestionably an almost inconceivable number of varying structures of these molecules. The simplest living cell contains, beyond question, a very great number of molecules of different composition and structure. Each of these molecules may be considered as a machine for the performance of certain duties in the life history of the cell. The chemical structure of the simplest of these living molecules is unknown—while it is living—but their variations are shown by the variations in their manner of reacting to external changes.

If these complex machines are structurally inefficient, the duties devolving upon them must be improperly performed. If the relations of the molecules with one another be compelled to vary from that to which they are adapted, they must be rendered more or less inefficient. In the living cell there are groups of molecules, apparently somewhat similar, arranged for the performance of certain functions. The nucleus is made of many such groups, differing from one another, and yet differing in a common manner from other groups of molecules in the cell. Any abnormal relation of nucleus and cytoplasm causes an abnormal condition of cell metabolism.

Structure of the Cell.

An experiment of Gerassimow's is very suggestive. By the influence of low temperature on the cell of Spirogyra caught in the act of dividing, he succeeded in driving all the nuclear substance into one daughter cell, leaving the other quite devoid of a nucleus. In a series of such experiments, it was seen that in twenty-one days the growth of the enucleated cell amounted to from four-tenths of one per cent to four and five-tenths of one per cent of the growth of the normal cell. That is, the most active of them all made only about one-twentieth of the normal growth, and the least active grew only one-two-hundredth part as much as did the normal cell. The growth of the other cells, with the excess of nuclear material, exceeded the growth of the normal cells by as much as seventy-eight per cent. At the same time, the solution of starch by the enucleated cell either did not take place at all, or proceeded very feebly; the outer cell membrane was less extensible than usual; the color of the chlorophyll bands became constantly paler and their contour less clear.

Loeb also has made experiments in determining the effects of nuclear changes upon the activity of the cell. Nothing which affects the structural integrity of any cell is without effect upon the metabolism of the cell. There is not yet found any exception to this statement.

Structural Relations of Cells.

In multicellular organisms, every cell must maintain its structural integrity if it is to maintain its normal function. It is the cell structure that must maintain its integrity. Things which affect the gross structure of the body are efficient causes of mal-function only as they affect the structure or the environment of the cells of the tissues. This is the reason why gross deformities so often cause such slight mal-function,—the cells have remained fairly normal in structure and environment. For the most part, however, any gross structural change does affect the structure and environment of the cells themselves.

Structural changes may be quickly and forcibly produced, or they may be the result of long acting forces, and be slowly caused. In the first case, the functional effects are usually intense; in the second case, the cells of the body may accommodate themselves to the slowly changing conditions, and the functional disturbances be comparatively slight. In the case of human beings the functional changes resulting from slight injuries are frequently not noticed because of the abnormal condition of nearly all bodies all the time. The human race, at its best, falls far short of the longevity, strength and beauty to which it is entitled. Failing in the perfection of function, further causes of embarrassment often remain a long time unnoticed. Another reason for the non-appearance of functional abnormalities is found in the fact that the human body has become adapted to a vast amount of ill usage, by being so constantly ill-used during its past history.

The discussion of causes and the nature of the effects produced by the structural changes of the tissues of the human body belongs more properly in text books dealing with osteopathic diagnosis and therapeutics, but a short resume may serve to illustrate the principles stated in this chapter.

Structural Relations of Complex Bodies.

Abnormal structural relations may exert direct pressure upon cells of the tissues. The body contains no waste spaces; if any tissue is misplaced it must exert tension or pressure somewhere, and it must itself be subjected to tension or pressure. Any pressure upon cells produces an effect which varies according to the nature of the tissues affected. No cells are able to maintain their normal metabolism for any length of time in the presence of abnormal pressure conditions.

Abnormal structural relations may partially or completely occlude the nutrient arteries of any tissue. The cells are thus starved for both food and oxygen. The effects produced are those characteristic of starvation throughout the whole living world. These phenomena vary to certain extent, but not in any essential feature.

Abnormal structural relations may partially or completely occlude the venous return or the lymphatic drainage from any tissue. The cells then are forced to continue their life processes, as far as they are able, in the presence of their own waste products. No cell is able to do this,—even the unorganized ferments cease their activities under such conditions.

Abnormal structural relations may exert pressure upon nerve trunks. The normal stream of nerve impulses is thereby more or less seriously impeded, and the function of the tissues affected suffers a corresponding embarrassment.

Abnormal structural relations may initiate abnormal nerve impulses. These may cause conscious pain, or they may occasion reflex nerve stimulation of a more or less urgent malignancy.

Secondary effects from all structural mal-adjustments mentioned are numerous. Any satisfactory discussion of these is beyond the limits of this volume.

COLLATERAL READINGS.

The Osteopathic Lesion, Carl P. McConnell, D. O., M. D., in The Journal of The American Osteopathic Association, May and December, 1905, and May and August, 1906.

Special Pathology of the Nerve Cell, in Mental Diseases, Henry J. Berkley.

CHAPTER II.

NORMAL FUNCTION IS ESSENTIAL TO NORMAL STRUCTURE.

So far as the life history of the unicellular organisms is concerned, their only function seems to be to eat, to grow until the ratio between the assimilative surface and the mass of the food-demanding protoplasm renders further growth impossible, then to divide into smaller cells which in turn eat, grow, and divide, and so on. In the economy of nature, there may be functions of races, as in our own bodies there are functions of parts, but this aspect of the subject does not concern us in this connection.

Perverted Functions.

Among these unicellular organisms, and among the simpler types of the multicellular animals, any lack of function is very quickly followed by a loss or change of structure. Under ordinary conditions, the normal cell in its normal environment does not fail to perform its normal function, nor does it exceed the normal limits of its metabolism. But under experimental conditions, factors which increase, decrease or change the activities of a normal cell may be employed, and the effects noted. Increased rest may be forced in the absence of light, or by lowering the temperature, or by decreasing the amount of food, water or air in a degree not incompatible with the maintenance of a fairly normal life. Increased activity may be secured by increasing the temperature slightly, by giving artificial light at night, by the use of electricity, by increasing the supply of food, and by increasing the oxygen content of the air. Other methods of especial application are employed also. Changed forms of activity, triangular cell division, abnormal forms of growth, abnormal metabolic products, may be forced by the use of more abnormal methods of stimulation or of restraining cell activity. The use of various salt solutions for this purpose has resulted in increasing the general knowledge concerning cell activity in many directions. The experiments of Loeb upon sea-urchins are of interest in this connection, as are also the experiments demonstrating the myogenic factors in the contraction of the heart and the non-striated muscles.

Abnormal Karyokinesis.

Triangular cell division, and other abnormalities of karyokinesis, result from the use of abnormal stimulants to increase or change the processes of cell division. If a culture containing fish eggs which are actively growing is violently shaken, many of the eggs will be killed outright, some will remain uninjured, and there will be some which will continue to grow, but because of their injuries will undergo the subsequent stages of growth in an abnormal manner,—the cells divide in a triangular or even a quadrangular manner, a second mitosis will be initiated before the completion of the first. Deformed cells result from these conditions, there are changes in the staining reactions, and other evidences of serious malfunction.

The cell division of the malignant growths, carcinoma, sarcoma, etc., display abnormalities of karyokinesis similar to those found present in the cells of the simpler animals which have been subjected to various forms of abnormal stimulation, or to the action of toxins, or to physical changes which injure without killing them.

Molecular Structure.

The changes in the structure of the cells which are affected by adverse influences are perhaps in part due to actual physical injury, but in other instances, where the stimulant has been very slightly different from those normally active,—as, for example, a very slight increase in the oxygen supply, or of sunlight, or of very dilute non-toxic salts,—the abnormal effect seems to be at first one of function, which itself is a change of molecular structure of the living protoplasm, and the series of chemical changes which occur therein. The chemical configuration of the molecule determines the nature of its chemical reactions, the quality of the end products of its metabolism, and its staining reactions.

Whether the phenomena of karyokinesis are essentially chemical or not remains to be determined by further investigations. It is evident, from the work done, that these phenomena are rendered abnormal by both chemical and physical stimulation, and under other conditions wherein the etiology is unknown.

Cell Starvation.

The metabolism of the cell may be rendered abnormal by a lack of the normal quantity of food. In this case, the unicellular organism suffers merely progressive starvation and death. The cell which is a part of an organ of the body suffers also from starvation, but it does not suffer alone. The relations of the different cell groups of the body have been somewhat fully discussed in another chapter. In starvation the cell fails in growth, and therefore fails in normal reproduction. The starvation may itself initiate reproduction, and the daughter cells are then smaller than normal. In some of the unicellular organisms, the lack of food or water initiates a condition of rest. The rest period may be spent within a membranous envelope, by which evaporation from the protoplasm is hindered. These facts indicate that under normal conditions changes in the function of the cell which answer environal changes may themselves be a cause of changing structure.

Cell Exhaustion.

If a cell is stimulated to increased metabolism by methods which are not very different from their normal conditions, they usually undergo a series of changes which vary very little for all forms of life. The deutoplasmic granules disappear, the protoplasm becomes clear, the vacuoles increase in size, if any are present, or are formed, if they were not present already, the nucleus becomes pushed to one side, the protoplasm swells, and then becomes shrunken. These changes occur with some variations in almost all cells subjected to over stimulation.

The changes which occur in the environment of any cell are its only source of energy. The cell is able to avail itself of this energy only under certain conditions, which vary with cells of different forms of structure. For the most part, animal cells derive energy chiefly from the oxidation of their food substances. If their environment offers food but no oxygen, they are unable to use the food. If their environment offers oxygen but no food, or if water is lacking, or if a proper amount of heat be not present, the cell is unable to avail itself of those favorable factors which are present. In these cases, the cell structure suffers a more or less rapid disintegration and death. Whatever may be the cause of any mal-function on the part of any cell, the ultimate effect is a structural injury to the cell.

Organic Mal-Function.

Among the cells which make up the organs of the body, the same principles apply. In bodies so complex as these, each organ depends more or less completely upon the normal activity of all other organs. It thus occurs that organs which are themselves normal, so far as our present methods of investigation determine, are subjected to the influences of other organs which are not quite normal, and the normal organ is thereby forced to act in a manner somewhat different from that to which it is accustomed. This condition occurs in efforts at compensation and adaptation. The series of events as a part of the life history of the individual or the race is on the whole beneficial, else would it never have persisted. The over work which is forced upon any organ, produces certain changes in the structure of its cells. These changes are characteristic of the cells affected, as long as the over work does not occasion actual exhaustion. In this case, the structural changes in the tissue cells are those already mentioned as following the fatigue of the unicellular organism.

If a nerve cell be stimulated somewhat in excess of the normal degree, the substance which represents the potential energy of the cell (probably the precursors of Nissl's substance) become partially disintegrated. The exhaustion of the cell is accompanied by their complete disappearance. If the over work is continued for a time, the substances which are used up by the cell are replaced from the nutrient lymph with more and more celerity. These quickly formed substances are the more unstable, and the neuron threshold is proportionately lowered. The molecular structure of the cell is thus changed by stimulation which represents an amount scarcely beyond the bounds of the normal. The progressive differentiation of the neuron systems in development and education is a manifestation of the principle, that the structure of an organ or cell varies in accordance with the demands made upon its function.

The muscle cell which is caused to act in a somewhat increased manner endures also characteristic structural changes. Its cells increase in size, and in many instances also in number. The efficiency of the muscle also increases, as is the case with the nerve cell. This increase in size and function is a normal characteristic of muscle, though under circumstances which are clearly abnormal the hypertrophy may attain a degree which is pathological.

Function and Differentiation.

Other cells of the body react to unusual demands in a characteristic manner. It is evident that the structural changes which occur as a result of functional changes are a factor in differentiation and development, in the adaptation of the cell and the body to changing environment, in the manifestations of disease symptoms as well as in recovery from abnormal conditions.

Effects of Deficient Mental Function.

Note A. The lack of function of the organs of the human body may be due to failure of the normal mental stimulation. The education of an individual may be so much at fault that he will fail to make efficient use of the energy which is offered him by his environment. The normal brain cells in their normal function incite the individual to rational endeavor, but because of irrational training, not every one replies to the impulses of the normal brain in a normal manner. The impulses which incite to normal endeavor are answered by compelled inactivity, or by forced efforts at pleasure; the impulses which incite to normal rest are answered by further stimulation. These abnormal reactions are the results of faulty education. They produce structural changes in the cells of the bodies, and these structural changes may be a fairly successful effort at adaptation to the abnormal environment, or they may be unsuccessful and so result in a pathological condition.

The mind which derives less than its full complement of energy from its environment fails in the work and the joy of life; the body which derives less than its full complement of energy from its environment fails in its possibilities of development.

CHAPTER III.

NORMAL ENVIRONMENT IS ESSENTIAL TO NORMAL FUNCTION.

The Cause of Human Endurance.

Normal individuals should be able to withstand much that is abnormal in their environment, if need be. Our bodies are not made stingily, just able to survive with care, but they are generously planned, sufficient to the demands of ever-changing foods, seasons and habits.

This adaptability, greater than is found to exist in all nature elsewhere, is probably the result of the weeding out of the unfit, such as has been unconsciously practiced from time immemorial by our progenitors. These ancestors of ours have subjected themselves and their offspring to such severe and rigorous training that only those whose bodies were able to withstand a tremendous amount of mal-treatment were able to live at all. If there be any inheritance of acquired traits, the influence of these was surely to render the race capable of enduring hardships. Our savage ancestors either survived or did not survive the rigors of winter, the heat of summer and the onsets of some diseases. Those who survived perpetuated their qualities. The race learned in this way to carry more of reserve force than was needed for the daily demands of life, since the person who carried little of reserve force lived only until some pressing exigency displayed his weakness. Not only must savage muscles be strong enough to tear the meat from the bones of the dying prey, but they must also be able to recover quickly from the wounds inflicted upon them by both prey and perhaps a hungry neighbor or two.

Those who recovered most quickly went to fight again most speedily, and thus proved their fitness to survive. This environment of hardship and excessive demanding perpetuated, if it did not actually produce, a race with superlative possibilities of endurance. Thus it is that the present generation are able to endure hardships both mental and physical under such trying conditions, to work in tropical or in arctic climates, at the sea-side or on the mountain-top, alone in the wilds, or in the crowded city where a breath of fresh air or a moment's silence are things almost unimaginable. Such adaptability has been purchased for us by our progenitors at the expense of hundreds of those weaker ones who perished, being unable to endure the hardships.

Present Racial Tendencies.

A more urgent endurance is now being secured by the demands of the environment of our own day. It is impossible to foretell the effect of the persistent nerve strain which broods like a whirling pall over every effort of our strenuous lives. Daily we see the unfit go down under the strain,—unfit to cope with the nerve strain, though not unfit for a rational existence. These perish daily and with them perish the possibilities of their attainments. That which they succeed in bringing to pass is the property of the race, and survives in spite of the death of the one whose work we preserve.

But there are too many who perish before they have finished their work. It is one characteristic of civilization, that the race inherits all that the race has done, even though the workman may have been childless. Now those who are finest of brain are often least fit to endure the stress of our present noisy, nerve-racking, competitive existence. We let these great minds die, and their promise dies with them.

No one can tell what the effect of this will be upon the future. Perhaps the ones who survive present conditions are the very ones who are best fitted to be the ancestors of the next generation. On the other hand, there is serious danger that our present haste is at the expense of that physical superiority which our primitive and unhurried ancestors have bequeathed to us. There is danger that in living under these very unhappy and strenuous conditions, we are securing the persistence of characters which we consider neither admirable nor truly strong. Present industrial and social conditions make for the perpetuation of selfishness and greed.

This is, however, only the superficial view. Naturally, those who make the most noise are those who attract the most attention. The quiet, sturdy folk, who pursue their unrufflled existence without being unduly affected by the tension and fury of their noisy neighbors, who choose rather the simpler and kindlier habits of living, perhaps these are holding fast the traits that will persist after this blatant turmoil has frothed itself away.

The environment of tomorrow's race depends upon the attitude of today's inhabitants. The physician of today should join all other thoughtful men and women in the consideration of this aspect of the matter. The sane and wholesome lives, full of the labor that upbuilds and refines both the worker and his neighbor, lives that are busy in profitable ways, with some playtimes in them that are joyous and refreshing, and with occasional glimpses into the broader aspects of life—such lives as these ought to be made possible for tomorrow's children.

Persistence of Rational Habits.

The rational habits of life are really within the reach of most people now, if they choose it. Most people do not choose the manner of their lives at all, but simply live that life which accident has led them into. Any one who has any vital interest in life would, if he chose at all, choose the conditions which would make for the success of that in which he is interested. It is simply impossible for any one to do the best work of which he is capable in the presence of an irrational environment. The reason so many errors in living are made, is that very few people think of the possibility of their work's being affected by the way they live, or that their pleasure in life can possibly rest upon any habits of their own. Even the people who do think of these things are very apt to be led into some dark and mysterious superstition. The simple fact that the laws of the universe are active within our own bodies, that health is simply the occurrence of a normal body in a normal environment, is a thing almost unheard of, and most unbelievable.

We may endure for a long time an abnormal environment, else there would be no one left to tell the tale, but in so doing we lose the possibilities of the best development. Work that is performed under a handicap can never be the best work. The more normal environment means the better work, the greater pleasure, the longer life, the saner and purer mind. The physician is the only person who is capable and is free to lead people into the more rational manner of living. Almost alone, the osteopath is free from traditions that so often cripple the teachings of others. Recognizing, as scarcely any others dare, the relations of cause and effect in producing disease and in facilitating recovery, the osteopath has opportunities for good in this respect that very few other people ever enjoy.

The rational habits of life bring their own reward. Any return to the normal environment will be persisted in, if it be a rational return, for the sake of the good there is in it. Many of the efforts toward the normal life are very irrational indeed. These perish. The rational efforts persist, and the normal life soon becomes second nature,—or, rather, the real "second nature," the abnormal habit, becomes forgotten, and the "first nature," or the normal existence, becomes recognized as such.

Noise an Abnormal Factor.

One bane of our modern cities is noise, and another is light, or the lack of light. The noise is really a very serious menace to the health of the nervous system. The continual storm of discordant noises that assails the ear all the day and all the night is a source of nerve strain which is scarcely appreciated by those who suffer from it most. For consciousness is not affected by noises a long time present, and yet the reflex actions continue to be initiated. The lack of conscious perception of noises preserves the power to attend to other matters, but it does not eliminate the exhaustion of the nerve centers produced by the stream of impulses aroused by the stimulation of the sensory nerves. Any long continued sensory stimulation is injurious, because of this exhaustion, even though consciousness be not affected. Indeed, if consciousness were affected by the noises in as serious a manner as the nerve cells are, the cities would soon become more quiet.

There is absolutely no excuse for the greater number of unearthly screeches and clangs which disgrace our streets. If the merely unneccessary noises were eliminated, and the others decreased to the degree sufficient to meet the requirements of modern living, no harm could result, and all the people would be placed in a much more nearly normal environment. This matter is being agitated in some cities, and the physician should be prepared to offer a rational opinion concerning the evils of every conditions affecting the general health of the people, and he should also give sufficient attention to the matter to be able to suggest wise methods for the correction of the evils as he sees them.

Abnormal Lighting.

Another abnormal factor in the environment of many people is an unequal and unpleasant distribution of light. Through the day, the sun shines unrelieved down into the deep wells of the streets, and is reflected from the walls of the buildings in a merciless glare. The presence of fine dust particles in the air renders the effect the more trying. The interiors of buildings are too dark, and the person who goes in and out has his pupils continually changing in size, but almost never exactly adapted to one light before another change occurs. At night, unshaded artificial lights stab the eyes at every turn.

Eye Strain in Narrow Streets.

Eye strain is increased by the narrowness and the crookedness of the streets. The intrinsic muscles of the eye are at rest only when looking toward objects at a distance. Among narrow and irregular streets, there is no opportunty for resting the eyes by looking at distant objects.

The air is contaminated in many useless ways, both in cities and in country places. Water and foods are too often impure. Swamps perpetuate insect pests. Flies and mosquitoes are not only themselves an annoyance, but they carry infectious organisms which increase the bad effects of wounds or of temporary diseases. All questions of both public and domestic hygiene lie within the province of the physician. The word "doctor" means "teacher." The word should in part return to its original significance.

The Value of the Normal Environment.

The whole essence of life is found in the nature of the reply which is made to the environment. The whole source of the energy displayed in life is found in its environment. The nature of the environment, then, plays a very important part in the determination of the quality of life. Given the ordinary life, in an environment which is wholesome, both for body and mind, and a good, wholesome, useful life will be the result almost invariably. Give the ordinary child bad air, stimulating and undigestible foods, let him sleep too much or too little, let him be kept attentive and excited, and unrestrained in self-indulgence, and a worthless and unhappy life will be the result. The extraordinary person may remain of pure and rational mind even under abnormal surroundings, but the ordinary person does not. Normal function of the brain cells depends upon their normal environment, and the mental and moral manifestations of any life are in large part determined by the quality of the metabolism of the cortical neurons.

The Normal Environment.

The normal environment of any individual is that which makes his life most useful and most happy through the longest term of years. It is the duty of the physician to endeavor, with all wisdom, to secure for his patients and associates as nearly this environment as possible, and to encourage all rational plans for providing a better environment for the folk of tomorrow than is possible for those of today.

COLLATERAL READING.

The Effect of External Influences on Cells. Tigerstedt's Physiology, p. 50, Edition of 1906.

CHAPTER IV.

THE NORMAL BODY HAS A HABIT OF HEALTH

Various forms of mal-function are prevented by what, for want of better term, we are calling "the habit of health" By this expression is simply meant that property of living cells which enables them to retain their characteristic metabolism for a time in the presence of abnormal conditions. Through centuries of progressive reactions to similar environal changes, the cell has acquired a certain conservatism in the rhythm of the metabolic changes which have persisted for so long a time. This conservatism, this fixity, this persistence in the straight and narrow path of inherited rectitude is what we are calling "the habit of health." The term is not altogether satisfactory, yet it is the best which has been suggested.

Habit of the Molecule.

The habit of health persists in the simplest types of cells. If we may employ the terms of Ehrlich's side chain theory in this discussion, we may say that the habits of the cell, whether of health or disease, are the functions of the affinities of the side chains of its molecules.

The side chains of the living molecule have affinities for certain food stuffs, etc., which are always found in the normal environment of the cell. The molecules or radicals which are attached to the side chains satisfy the affinities of the chains for a time, and are variously used by the cell either as a source of energy, or as material for building or rebuilding cell structure. If the substances for which the side chains have especial affinities are lacking in the environment, these affinities may be satisfied by other compounds and radicals chemically similar to the normal foods. If these related substances are essentially like the normal foods, no harm is done by the change. If there has been present in the environment more than one element of possible food value, a choice is proposed to the side chains.

Let it be granted, for sake of clearness, that there are two slightly different substances present in the environment of a cell, neither of which is the food stuff normal to the cell, which is lacking. Some of the side chains of the molecules of the cell will unite with each of these compounds, in all probability.

The Beginning of Adaptation.

One side chain unites with a radical or molecule which we will call "A," the other with the radical or molecule which we will call "B." The side chains whose affinities have been satisfied by "A" and "B" have certain duties to perform in the cell metabolism. These duties or functions are somewhat modified by the presence of "A" and "B" instead of the normal food stuffs. If this modification is such as maintains or increases the rapidity or the efficiency of the functions of the side chain which has united with the radical "A" and is such as decreases the efficiency or the rapidity of the action of the side chain which has united with "B," then "A" is more quickly used in energy formation or tissue building than "B." The side chain which has grasped "A" has then free valencies again. The same quality or position which rendered this side chain more liable to unite with "A" in the first instance is very apt to facilitate its second union with a molecule of the "A" type.

The use of "A" instead of the normal food stuffs exerts an influence upon the side chain with which it is united. This change in the function of the side chain affects the rapidity and the efficiency and the quality of the katabolism and the katabolic products of the entire living molecule, and, through these, of the cell of which these molecules are a part. This change in the cellular metabolism is the first step toward adaptation. During the time of the series of changing periods of free valencies and of satisfaction on the part of the side chain, the affinities are still most strong for the food stuffs originally normal to the cell, but after a time, when the series of chemical changes which make up metabolism have been many times repeated, the affinities of the side chain are for the molecule or radical "A." The food stuffs originally normal are then foreign substances.

The side chain which has united with "B," the one whose function in the metabolsim of the cell was somewhat retarded by its unlucky union, is rendered more or less inert by the presence of "B," or it may be that "B" is more or less toxic to the chain or to the cell, and destruction or death results. But there is some reason to believe that side chains whose affinities have been satisfied in a manner poorly adapted to the ultimate good of the cell are simply discarded, and are eliminated from the body of the cell as waste matter. These discarded side chains are sometimes of value to complex organisms in the presence of infection.

The living molecule persists in the rhythm and the affinities to which it has been accustomed, and this persistency is the habit of health which often preserves life in the presence of abnormal surroundings.

Cells have a habit of health which is the sum of the habits of its many and various constituent molecules. Unicellular organisms are affected by certain changes in their environment which usually make for the preservation of the life of the individual. For example, an increased degree of heat increases the motion of certain motile animals and plants. Lately many scientists are investigating the various forms of taxis and tropisms. These reactions all make for the preservation of life, in the long run, else would they not be.

Habit of the Body.

The cells of complex bodies, such as our own, enjoy a habit of health in superlative degree. The factors already mentioned are effective in these cells also, and other factors which are dependent upon the many generations of united living add to the conservatism of cell metabolism, and to the perpeuation of the rhythm of functional changes which are characteristic of these cells. The periodicity of hunger, thirst, sleep, of the increase in the amylolytic power of the saliva, of increased and decreased temperature during the day, with its concomitant increase and decrease of muscular power, the occurrence of the growth changes, of puberty and the climacteric, are all indicative of the power of this inherited rhythm of metabolic changes. The fact that these rhythms are all susceptible to variations in answer to environal changes is indicative of the origin of habit in the repetition of certain recurrent environal changes, and also of the power of living things to adapt themselves to further variations in their environment.

The mental aspect of habit is somewhat aside from this discussion, yet it is rather closely related with it.

Habit of the Mind.

Habits, in the accepted sense of the word, are almost altogether psychical in their origin. They are perpetuated, often, without the intervention of consciousness. The physiology of habit is a very interesting and inexhaustible subject.

In the beginning, a habit is a conscious reaction to certain bodily or external factors. The sensory impulses, whether somatic or visceral, whether originating in the body or in the environment, are carried to consciousness and there correlated with one another and with remembered experience.

The motor reaction is carried to the appropriate muscles, and the first action is performed.

Now when a nerve impulse is carried over a system of neurons, the threshold value of that system of neurons is lowered. This renders these neurons more easily stimulated than they were before, and hence they react to slighter stimulations than before. If the first reaction is frequently repeated, the lower centers become so easily irritated that stimuli utterly inefficient in the beginning are able to initiate the whole series of motor reactions. The habit is formed when the motor reaction occurs independent of consciousness. It is not needful to assume that the reaction is performed unconsciously, but only that consciousness is not involved in deciding the nature of the reaction.

From the purely psychical standpoint, the same factors are concerned. Those centers upon the cerebral cortex and in the basal ganglia which are most frequently used are those which have the lowest liminal value. These are most easily stimulated by external changes, and these therefore affect most strongly the nature of the efferent impulses aroused by the incoming sensory impulse.

It frequently occurs that in the presence of poor nutrition, auto-intoxication, peripheral irritations, and some other abnormal conditions, the neurons of the cerebral cortex are unable to preserve their normal metabolism. In such cases, the mentality of the patient is affected in some degree. There is liable to be an abnormal lowering of the liminal value of the centers which are phylogenetically the oldest, and the motor reactions to sensory stimulation are not modified by the considerations of altruism, delicacy and unselfishness characteristic of the normal mentality of civilized and cultured people.

Note A.—"Our habits make ourselves. What difference is there between individuals that is not measured by habit,—

habit of speech, of manner, of thought? To every change in our surroundings we give an answer back, an answer which may be speech, deed or silence, but which is always determined, or at least modified, by our habits of thought and action. The manner of this answer is invariably characteristic of ourselves, and is usually very little more than the manifestation of a habit. By means of habit, the thought of yesterday governs the action of today, the decisions of the child modify the gait and the speech of the man, the habits of our savage grand-parents are shown in the clinching of fists and showing of teeth in our own anger, the use of the ring in the marriage service, and the offering of food to our friends, without any regard for their hunger.

"The persistence of habits through the life of the individual, the family, the race, even through changing environments which overlay the original habits with a thousand modifications, renders it extremely probable that there is some structural basis for their development and perpetuation. In order to consider a suggested explanation of the formation of habits, it will be needful to consider for a moment some of the facts already demonstrated with regard to the structure of nerves and their actions.

"The brain and other parts of the nervous system are made up of small gray bodies, irregular in shape, known as neurons, or nerve cells, together with the tissues which nourish and support them. Each neuron has at least one long, fine fiber growing from its body, and not more than two. The strong, white cords called nerves are made up of bundles of these fibers, each with its own sheath, and all bound firmly together. The neurons vary greatly in size. It would take about twenty-five thousand of the bodies of the smaller to make a row an inch long, but others have a diameter fifty times as great. The fibers growing from the larger cells may be thirty or even forty inches long. There are hundreds of millions of neurons within the body. Each of these, like the other cells of the body, leads its own life, maintaining its own individuality, yet in a manner dependent upon the rest of the body, as, in a city, the baker depends upon the miller, the tailor, the teacher, and each of these depends upon every other. The blood and lymph bring food and oxygen to the neurons and carry their waste materials away. From this food the cell builds up its own body, and stores energy for future needs.

"Certain granules, first discovered by Nissl, are found within the bodies of neurons. These represent the storehouse of energy. These granules are of very complex and unstable composition. Their disintegration liberates the stored energy very much as the disintegration of gunpowder liberates energy. The granules are built up by the activities of the neurons just as the green coloring matter of leaves is built up by the activities of plant cells. The Nissl granules are far more complex than the coloring matter of plants, however. So unstable are these that a ray of light breaks down the granules of the neurons of the retina, a faint sound causes the disintegration of the granules of the neurons within the ear, the most delicate touch upon the end of the fiber growing from the neurons near the spinal cord to the tip of the finger breaks down the granules within the body of these cells. The energy liberated by the disintegration of these granules is called a 'nerve impulse.' Nerve impulses pass from one neuron to another through the brain, the spinal cord, and other neuron systems according to their structural relations.

"The granules in different parts of the nervous system vary greatly in stability. In neurons rarely used the granules are relatively stable. The frequent passage of impulses over neurons and neuron systems causes them to build up granules which are more unstable. That is, the granules of neurons, like nearly all other complex organic structures, are more easily broken down when more rapidly built up. All mental development and all training depend upon this progressive decrease in the stability of the granules within the neurons.

"The neurons which receive sensations are arranged in little masses just outside of the brain and spinal cord. These cells send fibers to all parts of the body, and by means of these we receive sensations of heat, cold, pain, touch, weight, sound, smell, taste,—indeed, it is by means of these cells that we receive knowledge of our own bodies and of the world about us. Each of these cells sends a second fiber into the spinal cord or into the lower part of the brain. The fiber branches within the cord, or the lower part of the brain, sending one division toward the higher centers and others to the neurons which immediately control the movements of the body.

"The neurons which control the movements of the body are called motor cells. They send fibers to the muscles, and the nerve impulse from a motor cell causes the shortening of that muscle cell with which its fiber is connected. These motor cells are found in the spinal cord and in the lower part of the brain. They are induced to send out nerve impulses to the muscles by the receipt of impulses from the sensory nerves or from the higher brain centers. The sensory nerve cells from any part of the body are connected with the motor cells sending fibers to the muscles moving that part of the body.

"Now, when an impulse passes over a certain sensory nerve, it reaches both the motor nerve cells controlling the muscles of its own area of the body, and the higher brain centers where consciousness is affected. At first, the impulse reaching the motor cell is not sufficient to cause the liberation of its energy. The impulse carried to the higher brain centers affects consciousness, i. e., gives the person a knowledge of the source of the impulse. As a result of this knowledge he sends impulses through the motor cells which result in appropriate action. The granules of the motor cells concerned are disintegrated and their energy set free as a nerve impulse which travels along the nerve fibers to the muscles whose motion is desired. The motor cells must then build up another set of granules, must store another fund of potential energy. These new granules are just a little more rapidly built up than were the old ones, and are therefore just a little more unstable.

"Every time the original sensation is repeated a part of the impulse from the sensory cells reaches the corresponding motor cells. If this sensation is always, or is frequently followed by the passage of impulses from the higher brain centers to the motor cells, the granules formed by these cells will become progressively more unstable, until a time will come when the impulses reaching them from the sensory cells will be sufficient to cause the liberation of their energy. This energy, or nerve impulse, travels over the nerve fibers to the muscles, and the movements which result are those which already have been so often repeated. The original sensation is carried to the higher brain centers, as before, but since the required movements have already been performed, attention is less and less vividly aroused until presently the whole series of events becomes mechanical,—the habit is formed.

"These 'short circuits,' if we may so call them, are formed in many of the lower nerve centers, but never altogether within the sympathetic system. The short-circuits which are formed through the spinal cord, or the medulla, or the mid-brain, are called "reflex actions." These are inherited habits,—the short circuits are established at or before birth. Other short circuits are formed through the cerebellum. By means of these nerve by-paths we are able to perform very complex co-ordinated movements without thought. Walking, dancing, knitting and such handiwork and dozens of other such complicated actions, at first learned with difficulty, at last seem almost to do themselves. The Island of Reil, or "speech center," affords another opportunity for short circuits. By means of this by-path, language becomes easy and vigorous.

"As the result of all these short-circuits, the higher faculties of the brain, freed from the necessity of attending to the minutiae of routine tasks, are able to attend the more fully to matters requiring decision.

"The possibility of the inheritance of acquired habits is one of the puzzles of our day. At present, there seems to be evidence to justify at least the tentative supposition that individuals inherit increased or decreased stability of nerve cells or systems, rather than any mental traits as such."—From the Osteopathic World, December, 1905.

COLLATERAL READINGS.

The Associative processes in the Guinea Pig. Jessie Allen, in The Journal of Comparative Neurology and Psychology, Vol XIV, No. 4.

Instinct in Man and Animals, J. P. Morat, The Physiology of the Nervous System, p. 421, Edition of 1906.

CHAPTER V.

THE BLOOD PRESERVES AND DEFENDS LIFE.

The Function of the Blood.

The normal cells of bodies so complex as ours live in an environment of lymph or of blood. The blood is the source of the lymph, so it is not far wrong to say that the blood, by way of the lymph, feeds the body, and is its most vigorous defender in times of danger. Since the blood receives the lymph after it is drained from the cells, it is also true that the blood drains the wastes from the cells, as well as brings them their food. The products of the metabolism of some of the cells of the body are of the most vital importance to other cells, and the products of the metabolism of all the cells may become of great importance in the metabolism of other cells.

Internal Secretions.

The products of the metabolism of the ductless glands, and of many other tissues of the body which furnish an internal secretion, are absolutely essential to the maintenance of normal function of all the other parts of the body. The ill effects of various mutilating operations is largely due to the lack of the normal internal secretions from the removed organs. In many instances, doubtless, the lack of the internal secretion is preferable to the presence of an abnormal organ, which is a menace to life itself, but the cells of the body have lived together so long, and have become so thoroughly adapted to living in an environment composed of one another, that not any organ of the body is to be considered as absolutely without effect upon body metabolism. The substances thrown into the blood by that tissue from time immemorial, and the other cells of the body have become so thoroughly adjusted to this substance, however inert it may seem, that its lack must never be considered a thing of no consequence. The internal secretions of all the tissues of the body affect all other tissues of the body to a certain very variable extent.

The Blood Plasma.

The blood plasma carries dissolved in it all the substances needed for the nutrition of every part of the body. Among all the diverse structures of our complex bodies, there is not one which does not find its requisite food stuffs in the blood stream. Yet it must not be considered that the complexity of the tissues which are nourished from the blood is indicative of any comparable complexity of substances found in the blood. The serum compounds are comparatively simple, and from these the cells build up their own variable and complex structures. There are only twenty-six letters in the English alphabet, and yet from these letters, many books, no one like any other one, have been written. Many books contain quotations from other books, and many cells use as foods the substances prepared for them by other cells. Many books are antagonistic to other books, and the compounds formed by some of the cells of the body are toxic to other cells of the same body.

Inorganic Salts.

The plasma and all the elements floating in it contain a certain proportion of inorganic salts. These are of considerable importance in the bodily economy, quite apart from their function in supplying these substances in proper amounts to the cells for their food. The osmotic tension of the body fluids varies according to the amount of inorganic salts dissolved in these fluids. The maintenance of the normal interchange of food stuffs and katabolic products between the cell and its environment is very dependent upon the maintenance of a normal equilibrium of internal and external osmotic tension. The blood serum provides these salts to the tissues, and the rapidity of the circulation of the blood prevents an unequal distribution of them, even when the various tissues are undergoing metabolism with very unequal vigor and quality. The function of these inorganic salts and their ions has been made the subject of recent experiments. This work has added much to our appreciation of the exceeding importance of these salts in controlling the activity of the muscles and glands of the body, and in maintaining the blood pressure at a normal point.

One of the serum globulins, the fibrinogen, may attract our attention for a little time, because of its importance in maintaining life under circumstances of accident, etc. Under normal conditions, it is simply one of the food stuffs of the cells. But when there is an injury to the blood vessels the fibrinogen, after being acted upon by the ferments set free by the injury, and by the calcium salts, becomes transformed into the fibrin of the familiar blood clot. The body is thus protected from the excessive hemorrhage from slight injuries, and the repair of wounds is facilitated. The formation of the clot is described very fully in the text books on physiology, so further discussion of the matter is not needful here.

The corpuscles which float in the blood stream are of great importance in the processes of recovery, no less than in the maintenance of normal metabolism.

The erythrocytes are chiefly, if not entirely functional in carrying oxygen. The erythrocytes vary with many nutritive conditions, and the amount of hemoglobin which each one carries is also subject to marked variation in abnormal nutritive conditions, and to some variation even in health. The amount of oxygen which is supplied to the tissue is absolutely dependent upon the amount of hemoglobin present in the blood, provided the supply of oxygen in the air in the lungs is normal.

Faulty Oxidation.

The character of the katabolic products of the cells of the tissues depends upon the oxygen supply. If oxygen is carried to the tissues in quantities equal to their demands, the katabolic products of the cells are normal,—that is, they are inert, almost harmless substances, usually neutral, or only very faintly acid in reaction. Carbon dioxid, water, urea, etc., are the most familiar of these. A deficient supply of oxygen to the tissues results in the excretion by the cells of partially oxidized compounds, acid or acid forming compounds which are characteristic of abnormal conditions of metabolism.

Some of these acid products are decidedly toxic in their effects, and these are the cause of the symptoms of auto-intoxication, of delirium in some fevers, of coma in diabetes, and of other symptoms produced in conditions of faulty oxidation processes.

These acid products reduce the alkalinity of the blood, and thus facilitate the deposits of urates in the joints and elsewhere. The bactericidal power of the blood varies with its alkalinity, partly because the phagocytes are not well nourished when the blood is deficient in the alkaline salts, partly because bacteriolysis depends upon a supply of nascent oxygen, and partly because most bacteria thrive best in an acid or very faintly alkaline medium.

A lack of erythrocytes or of the hemoglobin content of the erythrocytes is therefore a serious menace to health.

The Phagocytes.

The phagocytes are, according to Metchnikoff, the most efficient guardians of the body against bacteria and other parasites. They are very efficient in the repair of wounds, also, but they are not helpful in their accustomed manner when the blood stream is not kept well supplied with food and oxygen, or when it is permeated with the toxic substances resulting from abnormal metabolism or the retention of the waste products of normal metabolism.

The Blood a Scavenger.

The blood, with the lymph, acts also as scavenger. If the drainage of any cell or cell group be insufficient, or if the blood be filled with waste products of metabolism, the cells are practically forced to work in the presence of their own katabolic products. Their function is thereby impaired, and, if the abnormal condition be long continued, their structure is impaired also. It is not possible for any cell or cell group to maintain normal function in the presence of its own katabolic products. Even unorganized ferments, non-living as they are, are unable to affect the substances to which they are best adapted in the presence of the products of their past activity. The functions of blood and lymph in removing the products of cell activity are not the least important of their duties.

The Blood and Health.

In order that the blood shall be normal in quantity and quality only a few conditions are needful, unless the patient is suffering from some malignant blood disease. The most important requisite for the maintenance of a plentiful supply of good blood is that the blood shall be kept rapidly moving under a normal pressure. This condition is said to be the most important because if it is present the other conditions are almost sure to follow. For example, if the blood flows freely through the splanchnic region, a normal hunger is almost certain. If the blood flows freely through the lungs, normal breathing is practically assured. If the sensory nerves are freely supplied with blood at normal pressure, they will perforce carry impulses to the nervous system which will assist in orienting the individual into a normal relation with his environment. These things are not absolutely dependent upon the normal circulation, but they are largely affected by these factors.

Food and Blood.

Even the best conditions of circulation, however, are not enough to keep good blood very long in the absence of proper food. Under normal circumstances, the appetite may be considered a fairly efficient test. But it is scarcely possible to find the really normal appetite. The lives of civilized people are so complex, so hedged about by conventionalities, that it is not at all easy for the unhampered appetite to find appropriate food upon our tables. If foods of the several classes,—fats, proteids, carbo-hydrates, fruits, etc., were set before us daily from childhood, we should probably choose wisely that which our bodies require. But this condition is not found in the average household. Children are taught a fondness for the most unwholesome foods, and the utmost endeavor of the modern cook seems to be to spoil the greatest possible amount of good food in the preparation of the most injurious dishes short of actual poisoning. Because of this factor in education, and not because of any untrustworthiness on the part of the untrammeled appetite, the study of dietetics is essential to those who endeavor to life the race to higher plane of moral and mental and physical strength.

Under abnormal conditions, either of disease or accident, a well chosen diet may add to the blood those elements from which the tissues may be built with the least expenditure of energy by the digestive and eliminating organs. The diet should always be adapted to the requirements of the individual case.

Origin of Hemoglobin.

Hemoglobin is derived for the most part from the chlorophyll and chromophyll of plants, and from the hemoglobin and myohematin of flesh used as food. Therefore, these foods are indicated in the presence of a low color index. The use of flesh foods is subject to certain limitations; these should be considered in connection with each case. If any essential element of good blood is lacking, the diet should be so regulated as to supply the foods from which these elements may be built up.

It is needless to say that the best of blood cannot supply to the tissues oxygen which is lacking from the air in the lungs. Normal air to be inspired, and normal habits of breathing are essential to good blood.

COLLATERAL READINGS.

Coagulation of the Blood, in Tigerstedt's Physiology, p. 157, Edition of 1906.

The Hourly Variations in the Quantity of Hemoglobin and in the Number of Corpuscles in Human Blood. Herbert C. Ward, American Journal of Physiology, Volume XI, No. 4.

CHAPTER VI.

THE RULE OF THE ARTERY PREVAILS.

Blood Pressure and Lymph.

The function of any cell group depends largely upon the pressure of the blood in the vessels applying it. The cell is bathed in lymph, and this is derived from the capillaries. The flow of the nutrient lympth, while probably not altogether independent of a certain secretory activity on the part of the capillary endothelium, is yet almost absolutely subject to the laws of osmosis and diffusion. The variations in lymph flow due to changes in osmotic tension depend upon changes in the quality of the blood, in the quality of the waste material thrown off by the cells, and in the rapidity of the flow of the lymph by which the products of cell metabolism and the unabsorbed foods derived from the blood are carried away. The lymph varies normally according to the pressure in the veins and arteries, and the presence of substances in the blood which are the result of the metabolism of the various organs of the body, or are taken with the food. Under abnormal conditions, the lymph flow is affected by very many factors.

Variations in Blood Pressure.

The lymph flow depends in part upon the capillary pressure. This follows the pressure within the arterioles, and this in turn depends upon several other factors. Arterial pressure is increased by an increased rate and force of the heart's action, by an increased quantity of the blood in the vessels, by the contraction of the arterioles in the tissues of any marked area, or by any interference with the circulation through any organ or group of vessels. An increased secretion of certain of the ductless glands, notably the supra-renal capsules, increases the blood pressure both by initiating an increased force of the heart's action and by decreasing the caliber of the vessels. The manner in which this increase in the activity of the non-striated muscles is produced by these internal secretions is not yet understood. The blood pressure is decreased by a diminished rate and force of the heart's action, by anything which decreases the amount of blood in circulation, or by the dilatation of any considerable area of blood vessels.

The blood pressure is practically the same in all vessels of equal rank and caliber all over the body. The differences due to gravity, to the pressure of other organs and to other factors are not great under normal conditions. Under abnormal conditions, however, these factors become matters of serious import. When the vascular walls lose their tone, the influence of gravity dilates them most painfully, and the elevation of the part affected affords great temporary relief.

Blood Pressure and Nutrition.

When the arterioles in a given area are dilated, and the systemic pressure is low, the blood flows slowly through the dilated arteries and the capillaries. The interchange of gases and of foods is very slow. The diffusion of the proteids of the blood serum is always a matter of difficulty, only secured under normal circumstances by the maintenance of a high arterial pressure. During a period of low pressure, these may be scarcely diffused at all, and as a result the cells of the body may be insufficiently nourished, even though the blood itself be fairly normal. The blood itself does not remain even fairly normal if the pressure remain abnormally low for any great length of time. The hematopoietic organs are just as dependent upon the maintenance of a normal pressure within the blood vessels as are any other organs of the body. Digestion and assimilation fail in the presence of persistently low blood pressure, and the blood itself soon becomes very poor, in its serum constituents as well as in its anatomical elements.

Blood-Pressure and Excretion.

The absorption of the waste products of cell metabolism is also hindered during periods of low pressure. The return flow of the lymph is often retarded in these cases, and the cells are forced to maintain their functions as well as they may in the presence of their own excretions, as well as with a poor food supply. Normally, the carbon dioxid is carried from the tissues chiefly by the veins. The amount of any gas which can be absorbed by any liquid depends upon the temperature and pressure. Now since the temperature of the body remains fairly constant, it is evident that the absorption of gas by the blood varies directly with the pressure within the capillaries. In the presence of a low pressure the carbon dioxid normally formed by the living cells is not properly eliminated. This failure of the elimination of the carbon dioxid, together with the oxygen deficiency usually associated with it, is a source of several abnormal conditions of more or less discomfort and danger.

Blood-Pressure and Flatulence.

During digestive activity, a low pressure almost invariably causes the accumulation of gas within the digestive tract. The habitual occurrence of this symptom is itself a cause of an abnormal distention and later a dilation of the stomach or some part of the intestinal tract. Other evils follow in the train of such dilatation in the due course of events. The accumulation of gas, in itself, is a matter of grave discomfort and annoyance, and under some conditions may be a source of danger. The gases formed by the action of the digestive juices and bacteria upon the food stuffs in the alimentary canal are, under normal conditions, absorbed by the blood and eliminated from the lungs. In the presence of an abnormally low blood pressure, these are retained within the stomach and intestines, causing pain and considerable annoyance from borborygmi and eructations.

Blood-Pressure and Katabolism.

The metabolism of the cells in the absence of a proper exchange of oxygen and carbon dioxid varies greatly from the normal. The waste products of katabolism are not thoroughly oxidized. In normal metabolism the waste materials are almost neutral in reaction. The blood remains alkaline during any amount of metabolism when the normal oxygen supply and carbon dioxid removal is maintained. But when the proper balance between these gases is disturbed, the metabolism also is disturbed, and the katabolic products include complex, poorly oxidized compounds, acid in reaction, very variable in their chemical relationships and almost invariably toxic to the cells of the body tissues, and the akalinity of the blood is decreased.

The liver and the lymphatic glands, and perhaps other adenoid elements of the body render these substances inert. The kidneys, liver, and other depurating organs eliminate them from the body as rapidly as possible, but the powers of these organs are limited, and the symptoms of auto-intoxication are almost sure to occur sooner or later. The akalinity of the blood is lessened by the retention of the normal wastes, by the formation of the abnormal wastes, and by other factors concerned in the oxygen and carbon dioxid relation. The bacteriolytic power of the blood is decreased with the decrease in its akalinity.

Blood-Pressure and Secretion.

The activity of all the glands of the body is subject to variations in answer to variations in the blood pressure. Any gland, whether it possesses secretory nerves or not, is more active in the presence of high pressure than during a decrease in pressure. The effects of the action of the secretory nerves may mask the variations due to changing blood pressure.

In the case of the sweat glands, for example, the secretion may be almost or quite suspended in the presence of high pressure, or be increased during periods of low pressure. In all such cases, however, the action of the secretory nerves is effective only as a stimulation to the katabolic processes, the nerve influences are not effective in the absence of the zymogen granules from which the secretion is derived. Secretory nerves initiate the discharge of the substances already potentially formed within the substance of the cell protoplasm. The effects of the stimulation of the secretory nerves fail utterly after a comparatively short period of activity with a low blood pressure, or when the blood supply is deficient. When the blood supply is good, and the pressure is high, the serum proteids are more easily diffusible and the gland is properly nourished. The oxygen supply and the carbon dioxid removal are also facilitated by the higher pressure.

Variations in the action of the kidneys, especially, are known to depend almost, if not quite, upon variations in the rapidity of the blood flow. Secretory nerves have not been demonstrated in them. Given an abnormally low arterial pressure, the action of the kidneys is insufficient. Given an abnormally high venous pressure, the action of the kidneys is also deficient. Given a somewhat increased pressure, the action of the kidneys is also somewhat increased, but the persistent increase in the blood pressure so injures the renal cells that mal-function is produced, with the associated structural lesions.

Local changes in the vascular musculature, as well as changes in the systemic pressure, affect the activity of all glands. The changes in the metabolism of the ductless glands in these conditions offer a field for some very profitable work in investigation. The little study that has been made of clinical cases in which mal-function of these glands has exercised very deleterious effects upon the general body metabolism, seems to indicate that the action of these glands may be very dependent upon vaso-motor influences.

Blood-Pressure and Mentality.

The brain itself is not exempt from changes in its activity due to changing pressure in its vessels. Sleep is accompanied, and, in part at least, produced, by a lowered pressure due to a general dilatation of the systemic arterioles. Any considerable lowering of the blood pressure due to any cause is marked by a sleepiness, or by a stupid, dull feeling. In a series of experiments performed in the investigation of physical phenomena associated with mental conditions, it was noticed that the usual effect of mental effort is to increase the systemic blood pressure.

Conversely, the lowering of the systemic pressure by the experimental dilatation of the splanchnic arterioleswas followed by decided sleepiness and an inability to concentrate the attention in the degree to which the subject was accustomed. The contraction of the splanchnic arterioles by stimulating manipulations raises the systemic pressure and renders the mental processes more speedy and the mental pictures more vivid. If the increase in the blood pressure does not exceed the degree normal to the individual, the experimental increase of blood pressure was followed by a consciousness of well being, and by a very rapid, pleasant, and vivid flow of mental processes.

Blood-Pressure and Alienism.

Under abnormal conditions the effects of changing blood pressure in modifying mentality are much more pronounced. Melancholia and the apathetic psychoses are marked by very low pressure. Anything that raises the blood pressure in these cases in slight degree exercises a beneficial effect upon the neurosis. The excitable manias are characterized by abnormally high pressure. The insane manifestations of these are somewhat relieved if the systemic pressure can be decreased. The pressure changes in the psychoses are probably in part a cause of the symptoms observed, but it is also true that emotional reactions produce vaso-motor ėffects.

Under fairly normal conditions, a persistently gloomy attitude toward one's surroundings lowers blood pressure, and, on the other hand, a low blood pressure renders the gloomy view the easy one, and the cheerful aspect a matter of considerable effort. Reasoning from the normal conditions, it appears that the so-called functional psychoses are in part referable to the metabolic changes due to deficient or excessive blood pressure, together with the faulty elimination of waste products usually associated with such conditions.

Effects of High Blood-Pressure.

It is evident that the normal activity of any cell group requires the maintenance of a sufficiently high pressure in the arterioles. The effects of an abnormally high pressure are not less disastrous than are the effects of an abnormally low pressure. Too high pressure, if long continued, leads to an abnormal activity of certain organs of the body, and to their too speedy fatigue. The kidneys especially are very easily injured by persistently high blood pressure. The phenomena of arterio-sclerosis ensue, if the walls of the blood vessels are long subject to too high pressure, especially if the blood contain toxic irritants which render the cells more unstable than is their wont. The walls of the blood vessels are subject to various pathological conditions when they are kept under too great tension for a sufficient length of time. The heart, also, is injured by the maintenance of too high a pressure.

The Regulation of Blood-Pressure.

The action of the arterioles in maintaining a normal degree of pressure in the blood vessels is kept regulated by the vaso-motor nerves. These are axons of the sympathetic neurons, which receive their stimulation from co-ordinating centers in the viscero-motor nuclei in the spinal cord, medulla, pons and mid-brain. Any interference with the pathway by means of which the nerve impulses are carried to or from the co-ordinating centers, must lessen the normal relation between the vascular dilatation and the functional activity of the different tissues.

Any condition which abnormally increases the activity of the vaso-motor centers causes an abnormal vaso-constriction, and any condition which abnormally decreases the activity of the vaso-motor centers causes an abnormal dilatation of the vessels. If the vessels are permitted to remain for a long time dilated, the area of their distribution is injured, and the other organs of the body are subjected to a decreased blood pressure. If the vessels of any tissue are forced to remain contracted for any length of time the tissue undergoes a degenerative process, and usually, if the condition be not relieved, gangrene ensues. The gangrene of ergotism is of interest in this connection.

Under normal conditions, the vessels of any organ become dilated during its activity. At the same time, and in answer to the same nerve impulses which cause the local dilatation, the vessels in other parts of the body become contracted, so that the pressure of the blood in the dilated arterioles remains high,—perhaps even becomes higher than before the local dilatation occurred. Sometimes, under abnormal conditions, the vaso-motor impulses are not properly co-ordinated, and the dilatation of the vessels in the active structure is not accompanied by the general vaso-constriction. In such a case, the general blood pressure is lowered, the functional activity of the whole body is lessened, and the elimination of the waste products of such metabolism as does occur is decreased. The active structure whose vessels are dilated lacks the normal pressure, and its function is thereby lessened. This mal-function and the abnormal conditions of pressure and nutrition initiate sensory impulses, which, reaching the vaso-motor centers, effect still further dilatation of the vessels in the organ or cell group whose activity has caused the whole series of reactions.

The co-ordination of all, or nearly all, of the vaso-motor nerves of the body is essential to the normal activity of any important organ or cell group. This co-ordination fails under the following conditions:—

Local abnormalities of structure may interfere with the normal passage of sensory impulses from any part of the body or of vaso-motor impulses to it.

Nerve trunks may be subjected to the steady pressure which decreases their power to transmit impulses, or to pressure which varies, as the pressure of a pulsating artery, etc., and so exercises a continual stimulating effect upon its fibers.

Mal-positions of the vertebrae may either increase or decrease the activity of the subsidiary centers, by initiating abnormal sensory impulses.

The neuron threshold of any center may be either abnormally raised or abnormally lowered by abnormal conditions of nutrition or function.

Abnormal structural conditions of the heart or of the vessel walls may render them inefficient, in the presence of the normal nerve impulses.

Abnormal impulses from the brain, especially from the basal ganglia, may interfere with the action of the lower centers.

COLLATERAL READINGS.

Ergotism, Osler's Practice of Medicine.
Raynaud's Disease, McConnell and Teall.
Raynaud's Disease, J. L. Adams in A. O. A. Case Reports.

CHAPTER VII.

THE NERVES UNIFY THE ORGANS OF THE BODY.

Need of Unity of Function.

The metabolism of the multicellular animals differs from that of the simpler animals and from all plants in the need for some method for unifying the functions of the body. Unicellular organisms or the cells of undifferentiated tissues react to their environment each for itself, with no apparent regard for the conditions of their neighbors. Plants, even of considerable complexity of structure, exhibit no correlation of activity such as is displayed by even quite simple animals with nervous systems. Plants make no speedy reply to changes in their environment; their adaptation also is very slow; they live the life prepared for them by their ages of inheritance.

The same conditions are true of those simple animals which have not attained the dignity of a nervous system. These do not lack for the unifying powers of the nervous system, because their cells are not differentiated and so act all alike, each in answer to its own environment. Such simple animals do not quickly adapt themselves to changes in their environment.

They display very remarkable instances of regeneration of lost parts, but make no very evident efforts toward compensation. In animals which possess simple nervous systems these seem to exercise some control over the processes of regeneration. Among the higher animals, with their well organized and efficient nervous systems, the phenomena of regeneration disappear, and are superseded by the phenomena of compensation. Regeneration is not altogether lacking in our own bodies, as, for instance, the epithelial cells are continually being regenerated and continually being lost.

The large and complex bodies of the higher animals and of man could scarcely survive were it not for the unity of action secured by the action of the nerve centers.

The Function of Nerves.

Loeb refers to the nerves as "bridges of protoplasm uniting the sense organs with the muscles." The nerves are bridges which unite the various structures with their various functions into an integral whole. The nerve cells, with their unstable protoplasm and their long unbroken filaments so well adapted to the transmission of the metabolic conditions of one part of their substance to all other parts, with their intimate relationship with skin, muscle, gland, and sense organs, with their rapid metabolism and with their long life, are surely well adapted to their function of unification. They unify the many activities of the body in health as well as in disease; they unify the individual of today with the individual of yesterday; they unify the individual with the other members of his race; by the action of the higher association centers, the race is unified in power, in needs, in aims, in attainments and in inheritance. The whole function of the nervous system is comprehended in the statement that it unifies the individual in his reply to his environment.

Individuality of Cells.

The cells of the body are characterized by a certain individuality of metabolism. They are in no case absolutely independent, yet they are in great degree individual. The adherents of the myogenic theory of the cardiac and gastrointestinal movements have demonstrated the very great degree of independent activity that is possible to the cells of muscles of even very complex bodies. In the absence or the disease of the nerves the muscle cells may act with a certain amount of rhythm for remarkably long periods, but in such cases there is no adaptation of the body as a unit to the environment as a unit. The heart kept beating without nerves, nourished by warm, defibrinated blood, may preserve its rhythm unchanged in any serious degree, but there can be no change in its force or rhythm in answer to the demands of active structures elsewhere in the body, nor does any fatigue of its own initiate vascular changes looking to its relief. The other parts of the body display analogous phenomena. Every cell and tissue leads its own individual life, and each influences and is influenced by almost every other organ of the body for the common good.

Nutritional Influence of Nerve Impulses.

Inasmuch as the cells of the body are adapted to the receipt of these streams of nerve impulses, they are not long able to maintain any degree of efficiency after the section of their nerves. The nutritional condition of almost all of the body tissues is dependent upon the maintenance of its normal relations with the central nervous system. In olden times the effects produced by the section of the nerves to any part of the body was thought to be due to the lack of the "trophic" impulses which were supposed to be carried for the most part with the sensory nerves. Later authors doubt the existence of these impulses as such, but recognize the value of the sensory nerves in initiating the normal stimulating impulses to the organ concerned, and the more important protective movements. It is probably the lack of the sensory impulses which is responsible for the abnormal nutritive conditions observed after section of the sensory nerves to any tissue.

In the case of the ulcers sometimes found upon the feet of the person with tabes dorsalis, for example, it is evident that it is the lack of the normal sensory impulses which is responsible for the condition. Here the sensory impulses aroused by slight injuries to the feet do not attract attention until the wound has become infected and the deeper tissues are seriously involved. Not only is it true that consciousness is not affected, but it is also true that the vascular reactions in answer to the variations of heat and cold and muscular effort either fail or become very inefficient in the absence of the normal sensory impulses from any organ. The presence of the trophic nerves has not been demonstrated, nor have the problems which occasioned their suggestion been satisfactorily solved. However these facts may be interpreted, it is indisputable that the section or disease of the sensory nerves to any part of the body results in its mal-nutrition and disease.

The Physiological Basis of Education.

All efferent impulses depend ultimately upon afferent impulses. Even the impulses called volitional are derived from sensory impulses which may have been a long time retained within the nerve cells. The character of the metabolism of the nueron is somewhat modified by demands made upon it,—every time that a neuron is affected in any manner its powers of reacting to its environment are affected. Under normal conditions, whatever stimulus reaches a neuron lowers its liminal value. Under abnormal conditions, the liminal value may be increased, or it may be lowered in an abnormal degree.

The effect produced upon the neurons by education is simply a lowering of the liminal values of the areas affected. If the education be wisely planned, the neurons are developed in a co-ordinated manner, not any one system at the expense of another; and the systems which associate the different cortical areas are not neglected. In the unwise systems of education of children, and in the unwise methods adopted by some physicians for the mental treatment of patients, the neurons of certain systems are developed at the expense of a lack of development of others. The result of such a procedure is not all that might be desired in the way of mental or physical development.

Memory.

The phenomena of memory depend upon the fact that the activity of a neuron or a neuron system lowers its liminal value. Because of the phenomena associated with memory, the individual of today is practically identical with the individual of the past. The neurons are the structures which retain the records of past experience, and they do this by means of the changes in their metabolism resulting from their activity.

The Basal Ganglia.

The basal ganglia co-ordinate the emotional reactions. These are a needful and essential part of life, a source of strength and of normal pleasure in both work and recreation. The normal activity of the nerve centers depends upon their normal relationship with the other neuron systems. The irrational methods of education which eliminate the consideration of these centers fails in its most important ends. Many a nervous collapse is due primarily to the effort to compel a conduct of life based upon the action of the cortical neurons alone.

The Body a Unit.

If the body is to act as a unit, the neuron systems concerned in every reaction must be developed in equivalent degree. This is a problem for both educator and physician, it is true, but it is the failure of the educator which sends the abnormal nervous systems to the physician. It is here, again, that the physician fails in his duty if he neglect the instruction of his patient in the rules of hygienic living.

COLLATERAL READINGS.

Collateral Readings.

Tabes Dorsalis, in "Mental and Nervous Diseases" by Church and Peterson.

The Physiology of the Brain, by Jacques Loeb.

CHAPTER VIII.

ALL STRUCTURES INNERVATED FROM ANY SEGMENT OF THE CORD ARE AFFECTED BY SENSORY IMPULSES REACHING THAT SEGMENT.

This statement is known to be true for every structure subjected to experiments demonstrating their nerve relations. For organs of the body which have not yet been subjected to experiments in this line, since the structural relations of the neurons affecting them are such as to facilitate the functional relationship suggested, we may conclude that these also are affected by sensory impulses reaching the segment from which their motor and viscero-motor impulses are derived.

The Sensory Neurons.

The structural relations of the neurons concerned in this functional relation are as follows:

The sensory neurons are those whose cell bodies make up the spinal ganglia. These lie in the intervertebral foramina. The peripheral outgrowths from these cells are distributed to the various tissues of the body and terminate in the remarkable structures called sensory end organs. These peripheral branches from the sensory neuron body Van Gehuchten called dentrites, a name which is very appropriate from the anatomical as well as from the functional stand-point, although nearly all the authors on the subject persist in referring to these cells as being bipolar, and of the peripheral termination as an axon. Every writer agrees that the central prolongations of the sensory cells are axons.

These penetrate the cord as its posterior roots. Each axon divides immediately upon entering the cord, in a T-shaped manner. The shorter of these branches passes downward for a distance not exceeding two or three of the spinal segments. The long branch passes upward to the nucleus gracilis or the nucleus ceuneatus. Both these branches give off collaterals very freely near their point of division. These collaterals are concerned in carrying the sensory impulses from the periphery to the motor and association neurons which initiate and co-ordinate efferent impulses.

Relations of Sensory Neurons.

Collaterals form synapses with the cells in the anterior horns of the cord. These anterior horn cells send axons to the striated or skeletal muscles. By means of this relationship sensory impulses initiate reflex contractions of these muscles.

Collaterals form synapses with the cells in Clarke's column. The axons of these cells pass to the cerebellum. By means of this connection muscular movements are co-ordinated, and equilibrium is maintained.

Collaterals form synapses with the cells in the lateral horns. These send axons by way of the white rami communicantes to the sympathetic ganglia, and these in turn innervate the non-striated muscles of the body. By means of this connection, sensory impulses from both visceral and somatic structures affect the vascular and visceral muscles. (Note B.)

Collaterals form synapses with the cells in the posterior horn. The axons of these cells enter into relation with cells in the gray matter of the same and adjoining segments, both of the same and the opposite sides. By means of the interference of these cells, the complexity of the reflex pathways is greatly increased.

Viscero-Motor Nerves.

These structural relations are the same for all, or nearly all, of the cord segments. In the extreme lower portion of the cord there seem to be slight variations in the arrangement. In the cervical and lumbar portions of the cord there are no lateral out-going white rami communicantes, but the axons of the cells of the lateral horn pass through the white matter of the lateral mixed tracts to higher or lower levels, where they terminate in the lateral horn or pass out directly with the anterior roots and help to form the white rami. The lateral horn cells also send out certain other groups of fibers, which make up the splanchnics, the erigens, and others. The centers in the floor of the fourth ventricle and the acqueduct which are viscero-motor in function also send out fibers which pass directly to the anterior ganglia of the sympathetic system. These are the visceral fibers of the third, seventh, tenth, and others of the cranial nerves. These viscero-motor centers in the floor of the fourth ventricle and the acqueduct have not been studied so thoroughly as have the cord centers. The problems offered by these centers are much more complex, partly because of the branchial divisions of the nerve centers, partly because of the changes in the relations and functions of the muscles and other structures innervated by the various nerve centers during the developmental changes, and partly because of other modifications due to the process of cephalization.

In spite of these complications, however, a close study of the structural relations of the nerve centers, both viscero-motor and somato-motor, in the medulla, pons, and midbrain, indicates that in the main the sensory impulses reaching any segment, or collection of neurons homologous with a spinal segment, affect all the structures innervated from that segment or neuron group. The principle as stated at the head of this chapter is almost certainly true for the sub-cerebral centers, as it is for the spinal segments.

Function of Segmental Reflexes.

The relations of these reflex actions as they are displayed in the spinal centers are of utmost importance in diagnosis and therapeutics. By means of these, the body is protected from injury, compensation is secured in the presence of mal-function or injury to organs, and recovery is facilitated. On the other hand, by means of the same reflex actions, the injury of any organ may be a source of embarrassment to others, and mal-function so produced may, in turn, affect adversely the tissues first injured.

Sensory Impulses from the Skin.

Sensory impulses derived from the skin initiate motor impulses to the muscles beneath the point of irritation. Within certain limits, the stronger the initial stimulation, the stronger and the more widespread are the resulting muscular contractions. Sensory impulses from any area initiate also changes in the blood vessels of the same area.

Excessive sensory impulses from the skin may occasionally affect visceral activity. For example, irritation of the skin of the back of the neck causes dilatation of the pupils.

Sensory Impulses from Articular Surfaces.

Sensory impulses from articular structures cause the contraction of the muscles which move the joint. Thus the joint which is subjected to any irritating influences is held at rest by the forced contraction of all the muscles which move it. This rest is at first a curative measure, but afterwards, if the irritation persists, it renders the joint useless.

Sensory impulses from a joint held in a position of strain initiate motor impulses to the same muscles. Any tension upon the tissues surrounding a joint may be a source of the same abnormal contractions. Normally, the movements of the joints are a source of the impulses which maintain the tone of the muscles. If any joint is held immovable, either by its mal-position or by the persistent contraction of the muscles which should move it, the sensory impulses from it are not normal, and the other muscles in central relation with the affected joint lose their tone and become "flabby" and inefficient. In clinic practice, it is not unusual to find the muscles in the immediate neighborhood of an abnormal joint severely and painfully contracted, while the more superficial muscles are limp and flabby.

Sensory Impulses from Viscera.

Sensory impulses from the viscera initiate the contraction of the skeletal muscles innervated from the same segment, as well as the changes in their own musculature and of the size of the blood vessels of their own area. The skeletal muscles most affected by these viscero-sensory impulses are those which remained unmodified during embryonic development. The limb muscles became so greatly shifted during their growth, and passed through so many changes, with the concomitant slight re-arrangement of the neuron associations, that the limb muscles are less strongly affected by viscero-sensory impulses than are the spinal and intercostal muscles. The limb muscles are somewhat affected by the viscero-sensory impulses, but the effect is usually slight.

Function of the Viscero-Somatic Reflexes.

The contraction of the spinal and intercostal muscles in central relation with a disordered viscus is at first of decided benefit. Upon the appearance of a mal-function of any viscus, the sensory impulses initiated by the irritation of its sensory nerve endings affect both its own activity and the activity of other structures innervated from the same segment, for example, the spinal muscles. The contraction of the spinal muscles sends other sensory impulses into the same segment, which in turn affect visceral activities. At the same time these impulses assist in lowering the liminal value of the neurons of the same segment, and so increase their efficiency. The disordered viscus thus becomes stimulated somewhat in excess of the usual amount, and is thereby aided to recovery.

It must be noted that the stimulation thus sent to the viscus is not excessive in view of its embarrassment, but is in excess of that required under normal circumstances. After the disorder has disappeared, as it does if caused by some merely transient abnormality of environment, the stream of abnormal sensory impulses ceases, and the muscles are permitted to return to their normal condition of tonicity. This return to the normal condition is facilitated by the slight fatigue of the muscles and of the neurons concerned in regulating the whole series of reflex actions. This is the series of events as they occur under favorable conditions.

Viscero-Somatic Reflexes in Chronic Disorders.

When the disorder is not transient, as in the case of persistent wrong doing from the dietetic or hygienic stand-point, or of some incurable structural disorder, or of some continual nerve irritation from mal-adjustments of articular surfaces, or other more or less permanent causes of mal-function, then the persistence of these reflexes becomes a source of injury. The effect of long continued contraction of a muscle is to subject the sensory nerve ending within it to a functional paralysis. This condition is a matter of common experience, and is noted whenever any muscle is forced to remain contracted for too long a time, as in carrying a heavy burden too far. The muscles of the arm then are kept contracted too long and too strongly, and they feel numb and dead for some time. The return of sensation is accompanied by some pain. The same condition characterizes the sustained contraction of the spinal muscles, except that the condition is usually so slowly produced, and rest for the spinal muscles is so easily secured, that consciousness is not very often affected. The patient is not always conscious that there is any unusual condition of the spinal muscles at all until a physical examination is made.

Effects of Abnormal Muscular Tension.

The normal stream of sensory impulses from the alternate contraction and relaxation of the muscles affected is lacking, in these cases, and all the structures innervated from the same segment of the cord lack something of their normal nerve impulses. The contracted muscles themselves are not well nourished, since their blood vessels are subjected to continual pressure. The normal flow of the nutrient lymph is also impeded. The vertebrae are subjected to abnormal tension, and if the pull of the opposing muscles be unequal, they are apt to be drawn from their normal alignment. In any case, the tension exerts a pressure upon the structures surrounding and penetrating the inter-vertebral foramina, and subjects the articular surfaces to abnormal strain. The tension upon the articular surfaces adds to the sum of the abnormal irritation. The stream of abnormal sensory impulses aroused by these abnormal conditions is self-perpetuating, as is indicated by the structural and functional relations already discussed, and is only terminated by the exhaustion of the nerve centers, with their forced inactivity, or by corrective work upon the structures concerned.

Effects Upon the Spinal Cord.

During the period of the existence of such conditions as those just mentioned, the spinal cord itself does not remain unaffected. The circulation through the cord is controlled by vaso-motor impulses derived from its own lateral horns, but reaching its vessels from the sympathetic ganglia. Any abnormal activity of the cord exercises an abnormal effect upon the size of the vessels in that segment. An abnormal increase in the sensory impulses reaching any segment increases the activity of that segment proportionately, and thus increases the dilatation of its vessels to a certain extent. This effect is easily seen in experiments upon animals under anesthesia.

The neurons of the cord are variously injured by the constant congestion, according to the amount and persistence of the irritation, and other factors.

Vertebral Lesions.

The arterial supply to the cord and its membranes, the lymphatic and venous drainage, and both outgoing and incoming nerves pass through the intervertebral formina. Now when the spinal muscles are kept strongly contracted, especially if the tension be greater on one side than the other, the connective tissues around these foramina are subjected to considerable tension. The structures passing through the foramina are pressed upon in a manner that varies according to the direction and force of the contracted muscles and the structural peculiarities of the veretebrae affected. If the pressure is quickly removed the effect is transient and perhaps not at all abnormal.

If the pressure be long continued, the connective tissues, adapting themselves to the condition by growth changes, as is the habit of connective tissues, become thickened on the side of greatest pressure, while the ligaments which are subjected to the constant pull are weakened and lengthened. The slightly abnormal relations of the vertebrae thus become permanent, unless corrective work be done. The size of the intervertebral formina may be somewhat lessened by the thickening of the connective tissues, but probably the most serious effects are due to the abnormal tension upon the intervertebral vessels and nerves, and to the abnormal stream of sensory impulses from the contracted muscles and the articular surfaces.

Visceral Reflexes.

Sensory impulses from the viscera initiate motor impulses to the viscera. This reaction is constantly active during life. By this series of reflexes, the varied and complex processes of digestion, circulation, excretion, and all other visceral activities are carried on in a co-ordinated manner, without conscious effort or sensation. Under slightly abnormal conditions, the increased visceral activity facilitates recovery. Reversed peristalsis follows the ingestion of some toxins, for example; other toxic substances excite merely the increase of the normal peristaltic waves, with increased secretion. In many other instances familiar to every student of physiology the effects of viscero-sensory impulses in securing compensation are very evident.

All viscero-motor impulses are initiated by incoming sensory impulses ultimately, though in the case of certain cerebral conditions to be discussed in another connection, the impulses may be a long time retained within the nervous system before the visceral effects are produced. For the most part, however, viscero-motor impulses are reflexly initiated, and are therefore immediate. They are not usually segmental in any very circumscribed manner, but are more or less diffused.

The Sympathetic Ganglia.

There is yet great uncertainty as to the exact relation of the sympathetic ganglia in the co-ordination of the viscero-motor impulses. In a series of experiments performed in the laboratory of physiology of The Pacific College of Osteopathy, the cord was destroyed by thrusting a wire downward from the atlas. After this, no reflexes could be obtained by even the most urgent stimulation. If the cord were merely cut at different places, leaving the nerves uninjured for the most part, a procedure which must have occasioned at least as severe a shock as the destruction of the cord, the reflexes still persisted. These tests, which were repeated a number of times under very various conditions, indicate that the chief, if not the only, pathway of the visceral reflexes includes the spinal cord.

The constancy with which the viscero-somatic and the somato-visceral reflexes are noted is additional evidence in favor of the essential function of the cord in co-ordinating the visceral activities. The sympathetic ganglia are apparently relay stations for the increase or the diffusion of the impulses derived from the lateral horns of the cord and homologous cranial centers by way of the white rami communicantes, the vagi, the erigentes, and others of the same rank.

The lateral horns of the cord and homologous centers in the floor of the fourth ventricle and the acqueduct, are the immediate centers of origin for the viscero-motor impulses. These act in accordance with the algebraic sum of all the impulses reaching them.

Somato-Visceral Reflexes.

Sensory impulses from the skin, muscles, joint surfaces, and other somatic structures initiate viscero-motor impulses. The presence of these impulses is essential to the maintenance of the normal tone of the visceral and vascular walls, since any interference with the pathway of these impulses is followed by a decrease in the tone of the vessels and viscera affected. That is, the injury of the sensory nerves of the skeletal muscles or the skin in any marked area is followed by a loss of tone of the viscera and the blood vessels whose impulses are derived from the segment of the cord controlling the injured somatic structures. This loss of tone is temporary; other related structures compensate in part for the deficiency. Compensation is probably never absolute, however, here or elsewhere.

Normal sensory impulses from skin, muscle, joint surfaces and the like, initiate normal viscero-motor impulses to the vessels, glands, and visceral walls innervated from the same spinal segment; abnormal sensory impulses from skin, muscles, joint surfaces and other somatic structures initiate abnormal viscero-motor impulses to the same structures.

Effects of Structural Mal-Adjustment.

Now the effects of the mal-adjustment of the somatic structures vary greatly in their nature. Slight mal-adjustments of the ribs and vertebrae and other bones bring tension upon the joint surfaces and upon the surrounding connective tissues; this tension becomes a source of abnormal impulses which are at first productive of considerable visceral disturbance. Under favorable conditions, a more or less perfect compensation occurs, and the visceral reflexes become fairly normal. If the abnormal structural conditions be slowly produced, the compensatory reflex actions occur at the same time, and thus, while the deformity may be excessive, the visceral mal-function may be very slight. This is the case in Pott's disease. On the other hand, if the structural disturbance be suddenly produced, or if the compensation does not occur, the resulting functional disturbance may be very great, seeming out of all proportion to the apparently insignificant structural lesion. The nature of the visceral effects produced by any given injury depends upon the structural relations of the segment affected and upon the opportunity given the organs and their nerve centers for adaptation to the abnormal conditions.

Correlation Through Reflex Action.

These reflexes serve another very useful purpose in facilitating recovery from disease, and in this relation also, they may increase the evil effects of injudicious over work or over rest. Since the metabolism of any of the tissues of bodies so complex as ours depends in so great measure upon the impulses reaching them from the central nervous system, it follows that the metabolism of all the tissues innervated from the same segment of the cord must be somewhat related. Now this relation makes for health for the most part, else would the relation never have been established or perpetuated. By this means, any organ which is weak, or is being over worked, receives efferent impulses which have been initiated from the sensory impulses from stronger or rested organs, and it is thereby entitled to continue in a fairly normal condition much longer than it would were it affected only by the sensory impulses from its own sensory nerves.

On the other hand, this relationship works an injury to the normal organs in the presence of an incurable disease. The normal organs are forced to assist with the burden of the abnormal, and life may be shortened by the failure of the organs secondarily disordered. In such cases as these, the exhaustion of the neurons concerned often frees the normal tissues from the effects of the sensory impulses from the abnormal organ.

Volition and Visceral Activity.

This arrangement renders the non-striated muscles indirectly subject to volitional control, and this without permiting the possibility of injudicious interference with visceral activities. The visceral activities are well placed beyond the direct control of psychic influences which are so apt to be poorly planned and destructive.

Volitional control of the skeletal muscles is almost absolute and these may therefore be developed at will. Their metabolism is increased by their use, and sensory impulses from them to the central system are thereby increased. The passage of nerve impulses through any nerve center increases the metabolism of that center, lowers the liminal value of its neurons, and in this way increases the nutrition and the efficiency of all the tissues innervated from it.

This possibility is recognized in our methods of dealing with many of the disorders characterized by mal-nutrition or loss of function of certain viscera. For example, when there is lack of tone of the intestinal walls, any corrective measures are increased in their efficiency and recovery is hastened if the patient is instructed in judicious exercises which develop the abdominal muscles. These being strengthened, all other structures innervated from the same segment of the cord are also strengthened. The same principle is of value in facilitating cardiac compensation. The formation of ferments which facilitate muscle metabolism is probably another factor which is concerned in this relation between different groups of muscles. This aspect of the question is discussed in another chapter.

Note A.—Segmentation is the primitive arrangement. In the beginning each spinal segment is in relation with a pair of sensory and pair of motor nerves, a double set of muscles laterally placed, and areas of developing bone and skin, all innervated by these same nerves, and all fed by a pair of segmental arteries and drained by a pair of segmental veins. In the process of development some of the veins and arteries became atrophied, some of the muscles were shifted from their original position, some became excessively developed at the expense of others, while yet other muscles grew together or became divided. During all these changes, the muscles retained practically their original nerve supply. Even the muscles which were originally visceral and became skeletal during phylogenetic development retain their innervation from the lateral and viscero-motor nuclei, as in the days when they were visceral muscles. Notice the innervation of the diaphragm, the latissimus dorsi, and the limb muscles, the distribution of the vagus and the spinal accessory nerves as indicative of developmental changes; the spinal muscles and the intercostals are indicative of the persistence of the original segmentation.

In the cervical and cranial regions the relationships of the nerves are complicated because of the branchial divisions. The branchial divisions which may be recognized during ontogenetic development are complex enough, but many of the nerve relations of these structures are explicable only in the light of the study of the phylogenetic history of the branchiomeres.

Note B.—The axons of the sympathetic cells are not medullated. They leave the sympathetic ganglia, pass to the cerebro-spinal nerves, and are distributed, for the most part, with these. These bundles of gray fibers leaving the sympathetic ganglia and passing to the cerebro-spinal nerves are called gray rami communicantes. Some of these gray fibers enter the spinal cord as the vaso-motor nerves to the vessels of the cord.

COLLATERAL READINGS.

The Neurogenic and the Myogenic Theories of the Heart Beat, in Howell's Text-Book of Physiology, p. 497, Edition of 1905.

The Visceral Efferent Division, in Johnston's Nervous System of Vertebrates.

The Sympathetic System, Ibid.

CHAPTER IX.

NOTHING OF BENEFIT CAN BE ADDED TO THE NORMAL ENVIRONMENT OF THE NORMAL CELL.

Among the higher plants and animals there are many apparent exceptions to this rule, but when it is considered in connection with unicellular organisms it is almost self-evident.

The Paramoecium, for Example.

The paramoecium, for example, lives and thrives best in water containing certain salts, a certain proportion of organic matter, a proper amount of light and heat, and some other smaller living organisms for its food. If no other living organisms are present, the paramoecium can use certain nitrogenous compounds as food. After living upon these substances for a few generations, a culture of paramoecium may be able to thrive fairly well in a culture medium from which all other living things have been excluded. Such unusual conditions are endured with difficulty, however, and a return to the normal food conditions is hailed with every manifestation of increasing vitality by the survivors. If the life of the paramoecium were improved by the use of the non-living foods, those among them which should persist in ingesting bacteria, diatoms, and other tid-bits dear to the paramoecium's taste would soon lose out in the struggle for existence, leaving the paramoecium universe in the hands of those less blood-thirsty of their brothers who imbibe only non-living foods. It is needless to say that this does not agree with the facts in the case, as observed in the lives of these interesting little omnivorous animals.

The series of chemical changes which make up the life history of the paramoecium has become fixed by ages of inheritance in a certain definite routine. If the substances which have served as its food during its past history are not present, the affinities of the molecules of its living protoplasm may, perhaps, be satisfied by other substances which are found in the new environment, but the subsequent reactions, the evolution of energy, and the results of katabolism must of necessity vary from those characteristics of the paramoecium in the environment to which the paramoecium race has become accustomed.

This is true of all simple organisms, and is also true of the cells of multicellular organisms. Because they are adapted to certain conditions of environment, they find their best development therein. They may be placed under different conditions, if the change be slowly brought about, and they may become adapted to this environment.

Alga, for Example.

Perhaps the most conspicuous example of this condition is found in the behavior of certain of the fresh-water algae. These may be transformed into salt water forms by the gradual addition of sea-salt to their culture medium. If the change is made sufficiently slowly, the algae become transformed into true sea-water forms. The history of such a series of changes is written upon the shores of the Utah lakes.

The ancient Lake Bonniville was a fresh-water lake, and it was inhabited by fresh-water organisms. During the successive stages of evaporation which have intervened between that time and this, the fresh water forms have given place to those found in salt water. The remains of the plants and animals living in fresh water, in water slightly salt, in water more and more salt, are found upon the terraces which represent the shores of the lake at various stages of evaporation. There are limits to the possibilites of adaptation, however, and these lakes are now almost lifeless. This same history is written upon the the shores of many of the lakes through Utah, Arizona, New Mexico, California, and other places where there has been a slow and progressive change in the quality of the water in large basins. The history is occasionally reversed through a few chapters, when unusual periods of floods have diluted the salt water for the time of several generations of the smaller organisms.

Adaptation.

In the process of adaptation to the changing conditions, many individuals die, leaving the field to those who are able to make adequate reply to changing conditions. It is impossible to determine, at present, the nature of the difference between those animals and plants of any given species which are able to react to a changed environment and those which are not able to survive the change. It is probably true that the difference is represented by some difference in the chemical structure of the protoplasmic molecule, but there is no present evidence of the nature of this chemical change, nor of the manner in which these structures of apparently identical composition and inheritance differ from one another so much that one is able to exist under a new environment, while others perish in the attempt. In the very act of living under the new conditions, the survivors undergo certain changes in their metabolism which are represented in changes in their external forms, or in the quality of their reply to environal changes, or in their waste products, or in some other factors of their life history.

Essential Character of Life.

The essential characteristic of life is the power to make such reply to changes in the environment as must preserve the individual and the race. So long as the environment of the cell is that to which it has been adapted through its racial history, the reply will be for the ultimate good of the race. So long as the problems propounded to the cell do not vary in too great a degree from those propounded to its ancestors, its reply will be such as adapts it the changes which offer the problems. Every cell makes most rational and logical reply to those problems offered by the changes in environment which have been affecting its race for generations. Every unaccustomed change offers a new problem whose logical solution initiates a structural change subversive of the whole trend of its past development. Yet the possibility of making this change in its metabolism is the result of its life through all the past.

In this respect, the change is destructive of the species as such, though it is for the perpetuation of life in another form. To the normal development of fresh water algae, the addition of sea-water is fatal. There is no question of improvement in this matter. Under other conditions, there is probably a development of a greater complexity of structure in answer to the increased demands made upon an organism by a varying environment.

The Queen Bee, for Example.

The same principle is observed in many instances. In the queen bee, nothing but difference in food and care can be found to account for the development of the queen from the ranks of the workers. The environment of the queen developes the queen; the environment of the worker developes the worker. But the environment of the worker ruins the bee for a queen, and the environment of the queen ruins the bee for a worker.

The Human Body is Adapted to Human Environment.

The human body is the result of untold generations of progressive development. Its structure and the function of its parts have been subject to modification by environal changes as long as there has been any such thing as a human body. Every change in food supply, in climate or in the demands made upon the energy output of the body has initiated a reply which was either a logical reply and therefore facilitated adaptation, or was illogical, and therefore facilitated the elimination of those individuals who were unfit for the new conditions. In this manner the human body has become that which we now inhabit. It is fitted for a certain environment, to which it has been accustomed through all its past. This is its normal environment.

Human Organs Are Adapted to One Another.

This body is made up of millions individual cells, each with its own life history, its own inheritance and its own quality of development. Each lives its own life, yet not one lives its life alone. Not one cell of the body is absolutely independent of any other cell in the body. Under normal conditions it would be impossible to recognize a relationship between every cell and every other, but since the disease of any cell group may affect adversely the metabolism of every other cell group, there is beyond question a relation between them. Through the long generations of successive adaptations to changing environment, all cells and all cell groups have become adapted to the neighborhood of one another and of the fluids resulting from the metabolism of the various structures of the body as we now see it.

The Eyes, for Example.

For example, the eyes are adapted not only to the external conditions of light and heat and so on, found where eyes are likely to be needed, but they are fitted also to live upon the quality of blood which is formed by the hematopoietic organs of such bodies as ours. They are adapted to the effects of such nerve impulses as are likely to reach them from such nervous systems as ours, and to the needs of our bodies for eyes, as interpreted into the language of food or starvation, or the language of development, of the death of the unfit, of the persistence in inheritance of those whose eyes are a source of strength. The tension of the eye balls and their related structures is adapted to the pressure of the blood in the vessels, to the pressure of the capsule of Tenon from the back and of the eye lids from the front.

Adaptation Not Complete.

Every organ of the body is either already adapted to the conditions characteristic of the normal body, or it is in the process of becoming so adapted. If they are now perfectly adjusted to the environment made for them by the other structures of the body and the fluids formed by the various metabolic activities of the organs of the normal body, then the addition of foreign material to that environment must be harmful in just the degree in which the new environment differs from the old. If adaptation is perfect or practically so, the cell is already provided with its normal environment. It is evident, then, that nothing can be added to this environment which can benefit the cell.

If the adaptation of the cell to its environment is not perfect, because of the occurrence of changes in the environment, then a return to the original environment may be of benefit. In this case, the original environment is the one normal to that cell. If the cell is in process of adaptation to an absolute and inevitable change, the addition of other new factors could only still further complicate the problem offered to the metabolic capacities of the cell.

BASIC PRINCIPLES.

The determination of the normal environment of a complex organism is a matter of great difficulty. There is no doubt that not by any means all of the human race, or of the higher animals and plants are placed in absolutely their best environment. Inasmuch as physical conditons on the earth are constantly changing, and as complex organisms are, by virtue of their complexity, somewhat slow in their structural changes in reply to these changes, very few of the species now with us have become absolutely adapted to present conditions. In order to facilitate this adaptation, it would be very illogical to add another factor to the complex changes which already are offering so trying a test to the powers of the organism.

Any endeavor to assist the cell in its efforts at self-adjustment to a new environment can only result in an offer of a still different environment. It is evident that if abnormal factors are present in the environment of a cell, the structural and functional integrity of the cell may be preserved, or perhaps even restored, by the removal of the abnormal factors.

The Normal Environment.

The normal environment of the cells of the body necessitates the normal condition of all the tissues of the body. The normal relation of the cells to one another must be preserved. The normal environment of any cell is that which renders it capable of performing its function in the body in the best possible manner. The normal environment of the human body is that which makes inevitable the highest possible physical and mental development, which necessitates the performance of the best possible work in the world, which secures the maintenance of life in its finest expression through the longest term of years.

Note A.—The history of the chiefs of the Maoris is somewhat similar to that of the queen bee in this respect. The environment of the chief developes the chief, but ruins the lad for a tribesman. It is probably true, however, that the tribesmen were not ordinarily supplied with absolutely the best environment for their development as tribesmen. For this account of the Maori chiefs I am indebted to Miss Wilhelmina Sheriff Bain of New Zealand:

"According to native accounts, the tribal chiefs of New Zealand, and of Samoa and other South Sea Islands, were especially developed and maintained in physical perfection by frequent recourse to mud or steam baths, and by the kneading, massage, and other ministrations of their attendants.

"Towering above the common folk, with massive shoulders, proudly poised heads, and flashing eyes, these chiefs comported themselves as princes,—not always choosing to conceal their disdain for the puny proportions of some among their early white visitors who sought to intermeddle with their affairs."

CHAPTER X.

NOTHING BETTER THAN ITS NORMAL ENVIRONMENT CAN BE GIVEN THE INJURED CELL.

This principle is recognized as absolute in connection with the lives of protozoa. Among higher animals, however, there are occurrences which at first view seem in conflict with it. It is the function of this chapter to discuss those occurrences which harmonize with the principle as stated at the head of this chapter, and also those which are at variance with it, either in appearance or in significance.

Regeneration.

The phenomena of regeneration are of interest in connection with this aspect of the biological basis for rational therapeutics.

The nature and conditions of the regeneration of lost and injured parts have been investigated by a number of biologists, as these phenomena are displayed both by simple organisms and by those of more complex structure, including mankind. The investigations into the reactions of the simpler animals have added most to our knowledge of the processes of regeneration. This is due in part to the greater ease of investigating their physiology, in part to their greater capacity for regeneration, and in part to the greater simplicity of their life processes under both normal and abnormal conditions.

Temperature.

The effects of variations of temperature upon the regeneration of lost and injured parts has been studied by many persons. Even the most superficial resume of these experiments would require too much space in such a volume as this. Without any significant exception it is found that the limits of temperature at which normal growth may take place, represents also the limits of temperature for regeneration. The temperature which is the optimum for any animal during the time of its most active growth is the optimum for the most rapid and perfect regeneration of its lost and injured parts.

Starvation.

The regeneration which occurs in a worm, Planarian lugubris, has been investigated by Morgan with significant results. The effects of starvation upon its regeneration were first studied. This animal is very well adapted for this work, since it endures starvation remarkably well. The planarian is able to live until it has been starved to one-thirteenth its normal size.

If a planarian is cut into two equal pieces by a sagittal lengthwise incision, both pieces regenerate their lost parts, and two complete and normal worms are formed. In Morgan's experiments, one such half was kept well supplied with food, and the other was kept without food. The well fed half regenerated the lost parts rapidly, and the resulting individual was full grown and normal. In the starved animal, regeneration proceeded very slowly, and the resulting animal was very small, much less in size than the half immediately after the operation. It appears that this worm is able to reform its lost parts from the tissues which remain normal. It is shown also that the presence of a normal supply of food is essential to the most rapid and perfect regeneration.

Nevertheless, there are animals in whom the beginning of regeneration occurs more quickly during starvation than during full feeding. This is probably due to the fact that the material from which the new organs are to be formed is derived from the pre-existing protoplasm in the case of the starving animal. This material is more nearly of the chemical form of the new molecules than are the food stuffs which are probably used, in part at least, for the rebuilding of the lost organs by the well fed animal.

Light.

The effect of light upon regeneration has not been well studied. In the case of a hydroid, eudendrium racemosum, Loeb found that hydranths were regenerated in light but not in darkness, in blue light, but not in red. This hydroid is one of the few animals known in which light has an influence upon the direction of growth. It is, so far, the only one known in which the regeneration of lost parts is influenced by light. That is, in this animal, the same conditions of light which are best adapted to normal growth are also best adapted to the regeneration of lost parts.

Oxygen Supply.

A supply of oxygen is essential to normal growth and function, and is also essential to regeneration. If the stem of a tubularia, for example, is suspended so that it rests just above the surface of the sand, where the oxygen is somewhat deficient, the process of regeneration is either hindered or lacking altogther. If the stem is placed in a tube which it fits rather closely, regeneration usually does not occur at all. These points have been demonstrated by several investigators independently.

Nerve Impulses.

Among animals who rejoice in the possession of a nervous system, regeneration often depends to a certain extent upon the nature of the nerve impulses to the injured locality. Several biologists have found that when the eye only is cut from the eye stalk of certain crustaceae, (Palaemon and Sicyonia and one or two others), the eye is regenerated, but when the eye stalk is entirely removed an antenna grows in the place of the eye. This is held to be due to the fact that when the eye alone is removed the optic ganglion is left intact and the eye regenerated, but the removal of the entire eye stalk carries with it the ganglion, and the simpler structure, the antenna, is developed. Or, the regenerative attributes of the cranial structures are ordinarily effective in producing antennae, but the influence of the nerve impulses changes the character of these regenerative efforts in such away that the eye is produced instead. In any event, the normal regeneration of the eye depends upon the maintenance of the nerve impulses normally sent to the eye.

Even among human beings, the regeneration of a nerve trunk is facilitated by the maintenance of normal nutritive conditions in the area of the normal distribution of the nerve trunk affected.

The whole process of regeneration, recovery and hypertrophy are as much of a mystery as are all other physiological processes. It is not at present possible to offer any adequate theory for the explanation of the effects of nerve impulses upon regeneration.

In our own bodies, physiological regeneration occurs only to a slight extent. The most conspicuous example of physiological regeneration is displayed in the continual renewal of the continually wasted epithelial cells.

Normal Environment Facilitates Healing of Wounds.

Pathological or accidental regeneration occurs after injury to the skin, and to certain other structures. Only small areas of skin can be regenerated, but large areas may be healed by the multiplication of the cells of the connective tissues. In order to facilitate the renewal of the injured skin, the environment which facilitates the normal growth of skin is most effective. Normal skin cells which are undergoing the processes of reproduction are protected from bacteria and all irritating substances by the old, dead cells of the upper layers.

In order to render growth of the new cells most rapid and normal these conditions must be secured. The injured part must be protected from bacteria and irritants, as are the cells growing under normal conditions, and the heat, blood supply, etc., must be kept as nearly as possible the same as are present under normal conditions.

The healing of all injured tissues, of broken bones, sprained joints, bruised or cut, torn or burned tissues anywhere in the body is facilitated by those conditions which are normal to those tissues during their period of growth.

Regeneration in the Nervous System.

The number of neurons is fixed at a very early period of embryonic life. There is, so far as our present knowledge goes, no possibility of regeneration of nerve cells as such. There is apossibility of the development of embryonic cells, however, and thus the recovery from injury to the nervous system may be syptomatic, though it can never be absolute. The number of embryonic cells potentially capable of development is almost inexhaustible, under our present conditions of life. The processes of differentiation which rendered the neurons so irritable and conductible rendered them also incapable of reproduction. It did not render them altogether incapable of regenerating their own lost parts, however. The axons which are supplied with both the neurilemma and the white substance of Schwann may be regenerated after section, if conditions are favorable, and they may then perform their functions in a fairly normal manner.

After a nerve trunk is injured, the regeneration of its fibers may be rendered more certain, more perfect, and more speedy by securing the following conditions:

The ends of the nerve must be sutured. If the injury is an old one, the ends must be freshened; if the nerve has been crushed, the crushed part must be removed. Transplantation may be employed if necessary.

The blood supply to the nerve both above and below the injury must be kept free, both upon the arterial and the venous side of the circulation.

The blood itself must be kept good, by good food, good air, and good elimination.

The condition of the structures normally supplied by the injured nerve must be kept normal. This is very essential in the case of the muscles. They must be stimulated to a normal amount of exercise, in order that they may not atrophy. Not only is this done for the sake of having them normal when the connections are made, but their activity seems to exert a favorable influence upon the growth of the developing nerve fibers.

It is eveident that the factors which exert the most favorable influence upon the regeneration of the nerve fibers are just those which exert the most favorable influence upon normal growth and function.

Normal Environment Facilitates Recovery.

Cells within the body may be injured by various abnormal conditions in their environment. If bacteria are present, the cells which are in the most normal conditions of metabolism are those which are most efficient in destroying the invaders. If there has been injury to any part of the body, the environment which is normal to that part of the body during its period of growth is the environment which best facilitates recovery. There is no such thing as a "healing application" anywhere in all nature, except the things always present in the environment of the normal cells of the body. The normal environment of the normal cell during its period of normal growth is the best environment for the abnormal cell during its period of repair.

COLLATERAL READINGS.

Nerve Surgery, in The American Text Book of Surgery.
The Healing of Wounds, in any good text book of pathology.

CHAPTER XI.

AFTER ITS RESERVES ARE EXHAUSTED, ANY INCREASE IN CELL ACTIVITY NOT ACCOMPANIED BY INCREASED ENERGY SUPPLY MUST BE MADE AT THE EXPENSE OF CELL STRUCTURE.

It is, as every one knows, impossible to define life. This is not a matter of great importance when it is remembered that no one is able to define any fundamental thing. We know a great many things about light, and heat, and force, matter, the elements, and our own minds, but not any one of us has any adequate conception of the real, intrinsic nature of any element, or of a single form of force, or of the intellect that studies these things.

We may learn, and we have learned, many facts concerning these things which are of inestimable value to us in the daily demonstration of our reaction to our surroundings, but this knowledge is based upon an absolute ignorance of the ultimate nature of the very things which we consider most familiar to us. Our knowledge about these things is not of less value to us because we do not know the things. We must simply recognize our ignorance, and also recognize that it is at present incurable.

In like manner, we must recognize our inability to define life, while persistently engaged in the study of its nature, of its phenomena under various conditions. We may learn many things about life, just as we may learn many things about matter, or force, or the action of our own minds. The more we try to define life, to try to put into words what it really is, in terms of other fundamentals, themselves as unknowable, the more we are lost.

But if we recognize the futility of definitions, and content ourselves here, as in other sciences, with the investigation of phenomena, we may be able to solve some of the problems of living structure.

The Source of the Energy of Living Things.

If we resolve all the phenomena characteristic of life into their primal significance, we will find that every one is a form of reply which each living organism makes to its environment. Every manifestation of energy, every movement, every action of the ingestion of food, of the karyokinetic changes, of the psychical expressions, of developmental changes, both racial and individual; all these and all other manifestations of life are merely the expressions of an answer to environal changes. There is no expression of life or of living substance except such as is brought out in reply to environment. The manifestations of life are not manifestations of some intrinsic energy,—there is no intrinsic power in life.

The protoplasm which is alive has the power, or the quality, or the characteristic, of using in certain manners the forces of the inanimate world. The living protoplasm has no force in itself, any more than any engine has force in itself. This consideration is one of a certain importance. It is not essential that this fact be absolutely granted, but it is essential that every student of the phenomona of health and disease shall understand the nature of the problems which are offered for solution. This consideration rests upon the elemental facts of biological phenomena.

The Reply of the Cell.

If any cell is to preserve its identity the reply which it makes to its environment must, in a sense, be a selfish one. Every change in the environment must be made a source of energy. Food is a source of energy which is chiefly potential but is also kinetic in some degree. The sunshine, heat, electricity, all that is in the environment of any living cell, may be made a source of either potential or kinetic energy, or may induce a display of energy by stimulating increased metabolism, or it may serve as an energy sparer, either by being a non-conductor of heat, or by serving as a protection from other elements of the environment which might be a source of danger. There is no element in the environment of the cell which may not offer some factors in the problems which the cell has to solve.

The Source of Mental Energy.

Every source of mental energy, even the recognition of the most simple truth, depends upon changes in the environment. For mental strength, the changes in the environment must affect consciousness. The sensory nerves offer the only permeable pathway to the cerebral cortex, and there is at present no physiological basis for considering consciousness as affected in any other manner than by changes in the activity of the nerve cells in the cerebral cortex. It is evident that this activity depends upon the normal metabolism of the cortical neurons.

Every power that we possess, every action that we produce, every word and every thought, depend upon these two factors, the changes in environment, and the nature of the reply to these changes. Our own actions are merely the manifestation of forces derived from the physical world and translated into the terms of our own lives. One may write a poem with the strength derived from the oxidation of raw meat;

he may win a battle on toast and milk. The body is no more able to create energy than it is to create matter. There is no magic by means of which the cell or the body of a billion cells may be induced to do ten pounds of work on a six ounce diet, any more than there is some magic by which a fifty dollar clerk can live a hundred dollar life. In either case, the attempt is very apt to result in disaster.

No Royal Road to Health.

The older schools of practice were built upon a misconception of these facts. It has been supposed from time immemorial that by some priest-craft, or magic, or by the use of various drugs and simples, that the organs of the body might be induced to act more energetically than the state of their nutrition would warrant, and this to the upbuilding of the health of the body.

It is true that any of these things may increase the activities far in excess of the energy output warranted by the nutritive condition of the cells of the body. If the cell possess reserves of the complex molecules wherein are stored the potential energies of the cell, this evolution of energy may not be followed by any serious injury. But if the cells of the body were properly supplied with energy, the need for the drug probably would not be apparent. It is not usual for the normal cell to be subjected to abnormal stimulation. It is true that there are some people who do take medicine to keep themselves well, but these are scarcely to be considered seriously.

Under normal conditions, all cells, or nearly all cells, store within their bodies certain substances, variable in nature, which serve as reserves of potential energy. These are alike in some characteristics, though they differ so widely in function. They are all very complex in their molecular structure, and are so unstable that almost any change in the environment of the cell initiates their disintegration, with a corresponding evolution of energy. After these reserves are exhausted, stimulation of the cell may still cause a discharge of energy, but in this case the energy is produced at the expense of the cell structure.

Nerve Exhaustion.

The chromatolysis of the neuron has been very closely studied in this connection. The normal, rested neuron contains granules of a very complex nature, somewhat resembling nuclei in chemical structure, which are recognized only by their staining reactions. In the resting cell these granules, when properly fixed and stained, appear as rather large, angular masses lying in the meshes of the cytoplasm. The form and arrangement of these granules vary in different neurons. They are called Nissl's granules, after the name of their first describer. Nissl himself called them "tigroid substance." They are not found in the nucleus, in the axon, nor in a small area around the exit of the axon called the "implantation cone" or "axon hillock."

Effects of Fatigue.

In the cell which has been fatigued before death, or poisoned, or subjected to the action of various abnormal conditions, the tigroid substance can not be demonstrated in any normal manner. If the fatigue has been slight, the change may also be slight. But they are then found in smaller and smaller masses, with more and more difficulty in staining; and, after prolonged fatigue or mal-treatment the granules disappear completely, sometimes not even leaving a diffuse color in the cytoplasm.

In these cases of excessive injury, it is doubtful if recovery ever takes place, but very marked loss of the tigroid substance may be followed by recovery if the achromatic substance has been uninjured. That is, the cell is probably able to recover after the loss of all, or nearly all, of the tigroid substance which represents the reserve energy of the neuron, but it is seriously injured, and its ultimate recovery is doubtful, after the intrinsic cell structure is injured. It is very evident that stimulation of the fatigued cell may result in structural changes which are absolutely incurable as the result of an effort to secure the appearance of normal function under abnormal conditions. The neuron that is simply fatigued, even to the point of almost complete destruction of the tigroid masses needs only rest for its recovery; but this same neuron subjected to efficient stimulation, and forced to further evolution of energy may undergo irremediable injury.

Exhaustion of Muscle.

The muscles are protected from the effects of over work by the fact that the motor nerve endings are very easily fatigued. The muscle is thus freed from the motor impulses from the central nervous system before it is exhausted. This relationship is not an absolute protection, however, for it is possible for the muscles to remain contracted so long under circumstances of unusual stress, that an atrophy of the muscle results.

As a rule, the symptoms of disease do not attract attention until the depletion of the reserves has occurred. An abnormal stimulation, may then cause the destructive evolution of energy. The apparent symptoms of the disease are thereby lessened, but ultimate recovery is retarded.

Over Work.

The principle is as true of an excess of the normal stimulation as of the use of the abnormal methods. Persistent over work, especially under the influence of an emotional strain, is followed by a degree of exhaustion from which recovery is difficult and tedious. The absurdity of trying to overcome such conditions by efforts of the will power is evident. Mental conditions govern, they do not make or destroy energy. Inasmuch as they control many forms of physical activity, they must be considered as important factors in physiology and pathology and therapeutics, but it must not be forgotten that the only source of energy is the environment, and that every cell must be given, in the form of food, or air, or light, all the energy which it displays as muscular work, or nerve impulse, or glandular secretion.

It is just as rational to suppose that an amputated limb can be restored by the use of drugs, or by "will power," as to expect these things to add energy to physiological activities. These things compel the evolution of energy stored in the cell, perhaps as reserve force, perhaps as cell structure; the ultimate effect of this unusual stimulation depends upon the presence or absence of reserve forces. If these be present in sufficient quantity to meet the unusual demands, no greater harm than a waste of energy may result, but if the cells contain little or no reserve force, the reply of the cell must be secured at the expense of cell structure. The process may be compared to the old mills for grinding grain,—if there is no grist and the mill is turned, the mill-stones grind themselves away.

Emotions and Katabolism.

The influence of urgent volitional efforts and of various emotional attitudes upon the cells of the body may be mentioned in this connection. The emotional expressions are coordinated by the neurons of the basal ganglia. The structural relations of these ganglia with the cerebral cortex are such as to render the volitional impulses greatly increased in their power and in their effects upon the metabolism of the body when they are associated with emotional impulses. The effect of these impulses is always to increase katabolism. It is thus much easier for the body to become exhausted in the presence of intense emotional strain than under normal conditions. This is due in part to the partial unconsciousness of bodily conditions associated with emotional stress, but it is chiefly due to the katabolic effect of the emotional impulses themselves. The occurence of fear, or anger, or what not, does not add energy to the body; it only forces a more complete evolution of energy from the reserve forces of the cells, and, after their exhaustion, from the cell structure itself. The serious prostration which follows urgent effort under conditions of emotional stress is evidence in favor of this view.

The use of such simple and apparently harmless stimuli as heat and cold, water of various temperatures, massage, the increase of the patient's volitional endeavor, may in certain instances, though rarely, initiate an increase of cell activity at the expense of cell structure, and thus retard recovery. The exhaustion produced by the excessive use of these milder forms of stimulation is rarely sufficient to cause more than temporary injury.

Note A.—In some instances the use of abnormal forms of stimulation may be of value. In some cases where the normal stimulation is temporarily lacking, some unusual form may be substituted. The most noteworthy instance of this condition is found in cases of nerve injury. If a nerve has been cut, and its regeneration is hoped for, this result is more quickly and certainly secured if the muscles in the area of distribution of the injured nerve be kept in a normal condition. This can only be done by means of exercise. In the absence of nerve impulses, the exercise of the muscles is most efficiently secured by the judicious use of electricity. The muscles thus receive the nearest approach possible to their normal environment.

COLLATERAL READING.

The relation of Trophic to Nervous Functions in the Neuron, by L. F. Barker, in "The Nervous System."

CHAPTER XII.

ABNORMAL FUNCTION IS INDICATIVE OF ABNORMAL STRUCTURE OR ABNORMAL ENVIRONMENT.

The test of life is action. The test of the normal life is normal action, or function. Living structures are able to preserve a fairly normal life for a time in the presence of some abnormal factors of structure or environment; if the normal functions fail, there must be very urgent causes for the failure.

Normal Cells Act Normally.

Normal cells act in a normal manner. This is self-evident when it refers to the unicellular organism. The single cell must live if the conditions of its life requirements are met. The cells of the multicellular organisms are not of different order from those more humble neighbors. The cells of bodies so complex as our own live each its own life. It is not an absolutely independent life, it is true, but it is in a manner an individual life, and it is dependent upon the other cells of the body more because of their effect upon its environment than for any other reason. Each of these cells, if it has a normal structure and a normal environment, must live a normal life. There is no choice in the matter. The normal cell in a normal environment can not fail to respond to the normal demands upon it in a perfectly normal manner.

The Significance of Death.

This does not exclude death. It is part of the normal metabolism of the normal cell that its possibilities of maintaining its power of reply to its environment shall fail after a certain time, unless there is a certain recombination of its chromatic structure. This is true of every organism which contains within it the possibility of development. In the case of the lower animals and plants, this need for the recombination of the nuclear elements affects the whole organism. The paramoecium, for example, is able to divide by asexual division for about three hundred generations. Then the animals seem to be about to die of old age, they are small and not voracious, and they display evidences of failing nutrition. They die if the sexual division is not permitted.

Among the higher plants and animals, the cells of the body are able to divide in an asexual manner for years; some of the cells of the human body are able to continue dividing for a life-time, as is the case with the epithelial cells of the skin. Other cells lose their reproductive powers long before birth, as is the case with the nerve cells. These cells, and all the other cells of the body save only the reproductive elements, lose their power of sexual division, and in this very differentiation become limited in their possibilities of life. Thus it appears that death is one inevitable factor in the history of all the cells of the body except the reproductive cells, and for an almost infinite number of these also.

The death of individuals secures racial advancement. The unfit leave the world to the fit. Death makes progress no longer merely probable; it makes progress absolutely inevitable. It is the premature death which we wish to avoid, and the suffering that spoils lives. (Note A.)

The most complex body is made up of cells. These act normally if they have normal structure and environment. The activity of an organ is the sum of the activity of its cells. This activity is not whimsical,—the cells have no choice. They may be subject to injury, and their normal function be impossible. They are often unable to act normally because of starvation, or over work, or over rest.

No Disease Without Cause.

If the stomach, for example, fails in its function, there is some efficient reason for its failure. Usually faulty habits of eating are the cause of almost any indigestion. In other instances, the fault lies in an abnormal nerve or blood supply to the stomach. In other instances, there is some structural condition which renders normal function impossible. Always, there is some efficient cause for every fault of every organ.

The heart is an organ which fails in its duties sometimes, but it never fails without reason. This reason is not always apparent, but it so often is evident that there has been a history of infectious fevers, or rheumatism, or over strain, that it is beyond question that the normal heart never fails under circumstances that even approach the normal.

Normal Nerves Act Normally.

It is in considering disorders of the nervous system that this principle is most often doubted. It is perhaps never doubted in connection with these other conditions as a matter of theory, though it seems very often denied in the matter of deciding upon therapeutic procedures. Let it be granted that the faulty action of any organ is evidence of fault either in the structure or the environment of that organ, and the whole theory of the abnormal methods of combating disease becomes manifestly absurd.

In the case of nervous diseases, and especially the diseases which appear functional, there is great temptation to consider the nerve cell the offending organ. The next question which appears is the determination of the cause of the mal-function. The neurons are as dependent upon normal food and oxygen supply as the other cells of the body. They are as greatly subject to injury from the retention of their waste products as are other cells of the body. They are as easily subject to fatigue as are other cells of the body. They are more unstable than any other of the cells, and the effects of their mal-function are more wide spread.

There is no part of the body which may not be injured by a mal-function of the neurons. For these reasons, disease of the nervous system seems a primary condition, when it occurs. It is not a primary condition except when the structure of the neurons is itself at fault as a result of an inherited condition or some accident.

The neuron may inherit a structure which renders it weak and unable to endure more than the most ordinary burdens of life. These show the symptoms of approaching senility very early in life, or they fail utterly upon the onset of some unusual strain. These owe their lack of normal function to faulty structure. There is nothing for the physician to do in these cases except to give the disordered neurons the best possible opportunity for normal activity. These neurons, even with their faulty structure, may often be enabled to perform their functions in a fairly normal manner in an evironment which is unusually well selected. There must be no over work for the abnormal neurons, nor must their normal food fail, nor must they be permitted to endure the presence of any toxins at any time. In the normal life alone, with no demands save the absolutely normal, may the defective neurons be enabled to act in a fairly normal manner through a life time,—and the life time is probably a short one.

Normal Minds Inhabit Normal Bodies.

This principle must be held to apply to the mental conditions which vary only slightly from the normal. These cases offer some of the most puzzling problems which present themselves to the physician. There are many who doubt the existence of any real disorder in these cases and therefore prescribe placebos. These act upon the imagination of the patient for a time, but recovery never occurs under such circumstances. There is usually no urgent visceral trouble; if there is any at all it is usually due to injudicious medication or dietetic fads. These people are not often fairly dealt with. They are not sick in the manner they suppose, usually, but they are not normal people. It may be that their education has been at fault, in that case it is the duty of the doctor to remember the original significance of his title, and see that his patient is placed under conditions which lead to more rational and wholesome habits.

The normal brain is not gloomy and filled with baseless apprehensions, there is no place in the function of the normal metabolism for the occurrence of such affectations of ill health as fill the minds of the hypochondriac and others of his stamp. The very fact that a patient thinks he is sick when he is not is proof that there is some disorder, either in the structure or the environment of the cortical neurons. It not infrequently happens that serious causes of mal-function are overlooked by a busy physician because the patient displays evidence of the whining, self-conscious, self-pitying professional invalid. The appearance of these symptoms always suggests the malingerer or the hypochondriac, but it is manifestly unjust to suppose that there can therefore be no real disease. If the case of such a person is accepted, the study of the symptoms and the full investigation of the functions of all the organs of his body should be made as carefully as in any other case. In a large proportion of cases such a careful examination will display efficient causes for the mal-function. If these be recognized, the possibilities of a cure may be determined.

The term "functional disorder" is becoming more and more rare, and it is the hope of every person interested in rational therapeutics to see it disappear from our literature altogether.

Note A.—Plato's description of euthanasia is worth quoting: "But when the roots of the triangles" (affinities of the atoms, in modern tongue) "are loosened by having undergone many conflicts with many things in the course of time, they are no longer able to cut or assimilate the food which enters, but are themselves easily divided by the bodies which come in from without. In this way every animal is overcome and decays, and this affection is called old age. And at last, when the bonds by which the triangles of the marrow are united no longer hold, and are parted by the strain of existence, they in turn loosen the bonds of the soul, and she, obtaining a natural release, flies away with joy. For that which takes place by nature is pleasant, but that which is contrary to nature is painful. And thus death, if caused by disease or produced by wounds, is painful and violent; but that sort of death which comes with old age and fulfills the debt of nature is the easiest of deaths and is accompanied with pleasure rather than with pain."

—Dialogues of Plato, translated by Jowett.

CHAPTER XIII.

DISEASE SYMPTOMS ARE EFFORTS AT ADJUSTMENT TO ABNORMAL CONDITIONS.

Old Idea of Disease.

The series of phenomena which are called the symptoms of disease appear at first sight to be of such malignant and whimsical and illogical character that it is no wonder that in earlier times, and even to this day in some circles, people consider diseases as entities, as if they were wild beasts seeking whom they might devour. There is something ferocious in the attitude of the symptoms of sudden illness, and there is no blame to the ignorant person, who, seeing only the superficial aspect of the suffering patient, thinks of the disease as a cruel entity, to be propitiated or conquered.

Disease Not an Entity.

With such a vew-point, drug therapy is almost inevitable. If diseases are entities, if they have certain powers, if they perform certain malicious actions, then the rational thing to do is to expel, or kill, or counteract the disease, the creature which is making the mischief. Witch-craft sought to expel diseases, modern drug and serum therapy seeks to kill or counteract them. If diseases are malicious entities, and their symptoms are evidences of their presence, as the odor of an animal might betray its presence, then drugs of the most poisonous nature are rational enough, and the only question to be raised is one of the efficiency and expediency of these methods. They are, for the most part, found entirely wanting, even from this stand-point, according to the statements of those who have used them longest. But the stand-point is an untrue one, if there be no diseases as entities. It is true that certain groups of symptoms, usually found co-existant, have been studied and named, and our knowledge of these conditions has been greatly increased thereby, but it is not true that there is any real thing which may be called a disease.

The researches into physiological problems during the last few years indicate the utter fallacy of regarding diseases as entities. Disease symptoms are efforts, not at the destruction of the body by some more or less personal malignancy, but at the maintenance of existence under changing and abnormal conditions. Health is not an entity, either; both health and disease are abstract terms applied to conditions of metabolism.

Health is merely the condition of an organism which is perfectly adapted to its environment; disease is the condition of an organism which is not well adapted to its environment. When any organism is subjected to the influence of abnormal conditions, its metabolism is affected in various manners. The nature of the changes in the metabolism of the organism depends only in part upon the nature of the external influences; the character of the cells affected is a factor of equal importance. The activities of normal cells vary considerably under normal conditions, and are subject to great variations under abnormal conditions. Hence the nature of the effects produced upon the cells by any given abnormality in their surroundings may differ very widely at different stages of physiological activity.

Modifiable Organisms.

Loeb has shown that some of the simpler animals reverse their reaction to light under the influence of temperature changes. H. S. Jennings and Ada Watterson Yerkes have shown that among the unicellular organisms and the simpler multicellular organisms the character of the reaction to any stimulus depends in large part upon the character of the stimuli previously received. The behavior of these organisms is then said to be "modifiable." The nature of the reactions of these organisms is modified by the occurrence of previous stimulations. It would almost seem that the phenomena observed in these cases indicates a sort of education of the cell, if the expression may be employed without involving any considerations of consciousness on the part of these simple structures.

The Living Proteid Molecule.

The nature of the living molecule may be considered for a moment. The ultimate divison of living proteid matter that retains a semblance of life is too small to be seen with the microscope. That is, the very smallest bits of protoplasm that can be seen display signs of life, and it is probable that still smaller bits also live for a time. It is hardly likely that the limits of our present vision should coincide with the limits of the size of the proteid molecule. But the smallest bit of protoplasm that displays the powers of nutrition and reproduction must be quite large. It must include both nucleus and protoplasm in a certain amount.

Although the living proteid molecule is ultra-microscopic, it is known that the chemical configuration of the molecule is continually changing, and yet retains its individuality throughout its life time. This apparent anomaly becomes conceivable when the activity of the living cell is compared to a water-fall. Here, in a crude manner, is illustrated the phenomenon of continual change with retention of identity. In a far more complex manner, yet perhaps in some ways comparable to this, the cell retains its identity and its characteristics through changes almost inconceivably rapid and exhaustive. The central portion of this living molecule may be considered as fairly stable. Attached to this rather stable center are side-chains of very variable structure. There are certainly chains containing certain fatty acids, some containing carbo-hydrates; some apparently contain simple sugars, others hold oxygen in unstable combination and facilitate oxidation processes, and many are very complex nitrogenous side chains. The character of the foods that are taken up by the living proteid molecules depends upon the affinities of these side chains. The nature of the reaction of the cell to external stimulation depends upon the essential structure of the molecule and upon its position in the rhythm of its series of chemical changes. As illustrative of the first of these factors, we note that a muscle cell contracts and a gland cell secretes under the influence of identical stimuli; while as an instance of the second factor, we note the occurrence of the "latent period" of muscle and neuron.

Permeability of the Cell Wall.

Overton has studied the permeability of cells under different conditions. He finds that the substances that are soluble in water and also in organic solvents,—oil, ethyl-ether, the higher alcohols, etc., penetrate cells very easily. But the more the solubility of any substance in water exceeds its solubility in the organic solvents, the more slowly does it penetrate living cells. Overton suggests that the limiting layers of the protoplasm are impregnated with a fatty substance,—a mixture of lecithin and cholesterin, and that the elective solvent power of this mixture for different substances governs the pure osmotic permeability of the cells. If this be a justifiable conclusion, the accumulation of the products of katabolism might affect the permeability of the limiting membrane and thus affect the reaction of the cells to subsequent stimulation. The immunity of some cells to certain poisons, and the great susceptibility of others may be in part due to the nature of this "elective solvent power" and in part due to the affinities of the open side chains at the moment of the stimulation. The variations of the reactions to the same stimulus at different times may be accounted for in this way, perhaps.

Variations in Metabolism.

Many of these variations in the metabolism of the cells, or of animals or plants of higher development, form a part of their normal life or race history. These are not to be considered abnormal manifestations. The phenomena of metabolism are normal so long as the cell is able to reply to its environal changes in an efficient and logical manner; the phenomena of metabolism become abnormal when the cell is unable to give a logical reply to the changes in its environment. Or, in other words, the cell, or group of cells, is normal when it is able to secure from its environal changes the energy necessary to the perpetuation of its characteristic metabolism; it is abnormal and displays phenomena which we call the symptoms of disease when it is not able to make use of the energy supplied by its environment, in a degree sufficient to maintain its characteristic series of chemical reactions, or when the environment itself is abnormal.

Adjustment to Environment.

Because of this possibility of variation in cell metabolism, the cells (and cell groups) are able to endure certain changes in their environment. If the changes be slowly made, and if it be not destructive in its effect upon the cell structure, the cells may become adapted to the new environment, which thus becomes the normal. During this period of adaptation, the cell metabolism is not that which is characteristic either of the cells in the old environment, or of the acclimated cell. During this period of adjustment, the cell is not to be considered quite normal. It is more susceptible to the ill effects of temperature changes, is more erratic in its reactions to unusual stimulation. In the case of the higher animals, the cells are more easily fatigued, more liable to injury, and more susceptible to bacterial invasion. Ultimately, under such conditions, either adaptation is secured, and the new environment becomes the normal one, or the cells and organisms perish, as is the case with the manifestly unfit.

Causes of Disease.

Cells are unable to make rational reply to the changes in their environment under two conditions: The cell structure may be abnormal or its environment may be abnormal.

The cell structure may be abnormal from its first existence as an individual. The influence of heredity in maintaining peculiarities of structure is not doubted by thoughtful persons. This influence is not absolute, however, but is subject to modification by environal conditions.

Influence of Heredity.

The influence of heredity is to perpetuate the best of the race, for the most part. By varying combinations, and the tendency of those with unworthy characteristics to die young, the normal and sane characters leave greater effects of their lives upon the race than do the abnormal or insane, unless the abnormal conditions be perpetuated by continuous inbreeding. There is an inheritance of cell structure as well as of gross structure, as is shown by the occurrence in families of nutritional or metabolic traits. In the last analysis, these tendencies must be transmitted as peculiarities of structure, only in the one case it is a peculiarity of gross, and in the other of molecular, structure.

Given the faulty inheritance, the occurrence of disease symptoms is almost inevitable, under conditions of unusual stress, at any rate. It is true that the weakling may live a fairly normal life provided his environment remains fairly normal. The normal person is able to maintain normal conditions of metabolism under unfavorable conditions. The weakling fails in time of extra demands. The only thing to do for the person of faulty inheritance is to give him the environment that secures for him the best strength of body and mind of which he is capable. This varies with all individuals.

The gross structure of the body may be rendered abnormal by accident. This aspect of the subject has been discussed in Chapter I.

The structure of the body may be rendered abnormal through faulty function. By this is meant, that the environal changes may make excessive or unusual demands upon the powers of the cells or the cell groups, and the cells be finally injured, or the environment may not afford the available energy needful to the metabolism of the cell.

The Old Pathology and the New.

The older theories of pathology rested with the discovery of the abnormal structure of the cells of the organ whose mal-function was being investigated. The later investigations seek to penetrate further into the causes of the lack of cellular integrity. The osteopathic theories of pathology differ from those commonly accepted in this urgent demand for the causes of mal-function. The view that the normal cell may act in an abnormal manner unless it is affected by some abnormal factor in its environment is unscientific and primitive. Every rational theory of disease or therapeutics must recognize as a biological necessity that there is an efficient cause for mal-function,—that every symptom of disease is the manifestation of a changed metabolism of the cells of the body in reply to some abnormal conditions in their environment or structure.

Relations of Cells in Complex Bodies.

The cells of bodies so complex as ours have as their environment the other cells of the body, and the fluids formed by other cells. Thus, any mal-function of any cell may affect almost any other cell in the whole body. For this reason, the symptoms of disease may be grouped as the phenomena displayed by cells in their reactions to their environment; the phenomena displayed by cell groups, or organs in their reaction to their environment; and the phenomena displayed by the body as a whole in its reaction to its environment. These reactions are theoretically separate. Actually, the reaction of one cell group, or one organ, affects the reactions of others and of the body as a whole. For convenience, however, the simple classification may be retained here.

The effects of changes in the environment of the cells may be considered in some detail.

It is not desirable that every possible factor in the environment should be considered in this connection. The study of the significance of the symptoms resulting from a few of the changes in the environment of cells, organs and the body as a whole will serve to illustrate some of the principles underlying all disease processes.

Starvation.

The phenomena of starvation have been studied from the condition of starving cells and from the condition of certain organs of the body when their nutrition is interfered with. The starving paramoecium was studied by Wallengren. According to his observations, the food masses and the food vacuoles disappear first. Small granules, probably deutoplasm, disappear next, and the living substance of the endoplasm is then used as a source of energy. The cilia keep on waving, and the contractile vacuole maintains its pulsation at the expense of these structures until they are exhausted. The endoplasm becomes vacuolated, and just before all signs of life fail the cilia are absorbed, then the macronucleus, and the micronucleus persists longest of all the cell structures.

All that remains of the cell becomes granulated and the granules fall apart. Nothing is left but a mass of granular debris. This description of the starving paramoecium resembles the vivid picture which Berkeley gives of the neuron which dies of old age.

Fatty Degeneration.

Organs of the body which have failed to secure sufficient nourishment, or nerve fibers which have been severed from their cell bodies, or cells which have been poisoned, or which have been subjected to abnormal pressure, may undergo what is called "fatty degeneration." These conditions are probably all due to failing nutrition, in their ultimate nature. The occurrence of fat in these starved cells appears at first sight to be rather an anomaly. Leathes and his predecessors have found that much of the fat found in these tissues is derived from other less essential organs of the body. Another part of the fat found in starvation is accounted for in another way.

The living proteid molecule contains at least one and probably several side chains built upon the plan of the fatty acid radical. There is reason to believe that a partial disintegration of the living molecule sets the fat free. Leathes shows, in this relation, that the heart, the cerebral cortex, and degenerating nerve fibers contain actually less fat, by careful anaylsis, than do these tissues under normal conditions. Under normal conditions, these side chains do not give the micro-chemical reactions characteristic of fats in general, because they are in chemical union with the other parts of the living molecule. But it is possible to break them off, and to extract and estimate them as fats.

By the action of the autolytic enzymes during bad nutritional conditions, these side chains are set free from their feeble union with the rest of the living molecule, and they then give the micro-chemical reactions of the fats. Hence the old absurd idea that the fatty degeneration is a cause of disease.

Oxygen Starvation.

There also occurs a form of starvation not commonly considered as such,—oxygen starvation. Organisms of simple structure may live upon the oxygen derived from the disintegration of oxygen-containing compounds, but higher animals require this gas to be supplied to them free from "entangling alliances." Such complex bodies as our own require that the oxygen shall be brought to the cells in a very continuous stream. Oxygen starvation is sometimes characterized by an excessive storing of fat. The abnormal fatty accumulations found in persons suffering from cardiac lesions are due to the faulty oxidation. The condition is in no way different in its nature from the excessive deposit of fat which accompanies deficient hemoglobin percentages.

Hemoglobin.

The low hemoglobin percentages are often due to faulty nutrition, and this condition may be due to bad habits of eating, as well as to some digestive ailment. Ordinarily, starvation causes emaciation, but a lack of oxygen, either in the air, or in the blood and lymph, or because of a lack of the iron and phosphorus containing foods, may be accompanied by obesity. It is perhaps needless to point out the fallacy of suggesting starvation diet to the obese person who lacks hemoglobin enough to carry the oxygen requisite to the proper oxidation of the food materials, or whose heart is incapable of sending the aerated blood to the tissues in sufficient quantity to oxidize the food substances, or to carry away the waste products of cell metabolism.

Osmotic Tension.

The cells of all forms of life are very susceptible to changes in the osmotic tension of the fluids which surround them. The change in osmotic tension is not the only factor in modifying their metabolism when different quantities of salts are added to their environment, as is shown by the exhaustive work of Loeb and many other investigators into the physiological effects of ions in solutions. Though not the only factor, variations in osmotic tension are very effective agents in modifying the activities of cells. The structure of the cell is changed by variations in the osmotic tension either within its walls, or in its surrounding fluids. It absorbs water, perhaps until it bursts, or it yields its own fluids to its denser medium, until it becomes shrunken and dead.

The Cause of Swelling.

Under normal conditions the number of molecules within the cell is just sufficient to maintain a normal circulation of liquid into and out of the cell, in connection with the series of chemical changes which are devoted to the same end. If the function of the cell be subjected to serious interference, its very complex molecules become broken down into simpler compounds. This occurs normally under conditions of increased katabolism, but the rebuilding proceeds as fast, or almost as fast, as the breaking down. Abnormally, the anabolism fails in a certain degree. Under abnormal conditions, then, the molecules within the cell are simpler and smaller than normal, there are thus more of them from the numerical standpoint. Since the osmotic tension of any fluid varies according to the number of molecules present, without regard to their size, if the complex molecules are divided into simpler molecules of half the atomic weight, the osmotic tension is doubled. In a cell which has been injured, the molecules are simple and therefore greater in number. Therefore, the abnormal cell, however it may be injured, invariably swells first. The simpler molecules, being more diffusible than the larger ones, are slowly dissolved out of the cell, and the cell shrinks. This sequence of swelling and shrinking is present under almost every manifestation of disease of cells, either those living an independent existence, or those associated with millions of others, as in our own bodies.

Temperature Changes.

Changes in temperature exert a marked difference upon the metabolism of all living things. A slight increase in the temperature of the environment increases the motility of many unicellular organisms. This increased motility causes their escape from the harmful neighborhood. In like manner, probably, the cells of higher animals react to slight increase of temperature by increased metabolism. In animals with nervous systems of considerable complexity, the increased metabolism of different organs following increased temperature is co-ordinated in such a manner that the loss of heat from the body is facilitated, and the body temperature kept normal. Higher degrees of temperature are fatal. The resistance of some spores and seeds to high temperatures is very remarkable. Many of them remain alive even after having been boiled for more than half an hour.

Variations in the lethal temperature of the various living things depend upon the nature of their more complex globulins. The work of Brodie and Haliburton indicates that the lethal temperature of any animal depends upon the temperature at which its most complex globulins are precipitated.

The frog is accustomed to a low body temperature, and dies if kept very long in a temperature above 34° C. Even in glass, the extract from a frog's muscle forms a coagulum at a temperature of 34.5° C. The extract from the brain or muscle of most mammals does not give a precipitate until a temperature of 42° C. is reached Extracts from the brain or muscles of birds require even higher temperatures before the first coagulum is formed. This is in accordance with the facts of the resistance of these animals to heat. Birds endure temperatures disastrous to human beings; mammals endure temperatures fatal to frogs. These temperature figures apply to the temperature within the body itself, and takes no account of thermogenic and thermolytic regulation through nervous activity.

The Neurons at High Temperature.

Goldscheider and Flatau have studied the nature of the effects of heat upon the neurons. Small animals, rabbits and guinea-pigs, I believe, were kept in a warming chamber at a temperature of 42-44° C. for several hours. After they became apparently moribund, they were removed. Some were killed at once, others at various intervals during their recovery. Not all of them did recover, but some were able to regain their normal condition within periods varying from a few hours to several days, according to the animals, the length of time spent in the warming chamber, and other factors. The brains and cords of those killed at once upon removal from the warming chamber were prepared after the method of Nissl. Their neurons showed that the cell structure had become greatly changed. The tigroid substance had almost or quite disappeared. Its place was taken by light brown opaque masses and small granules. The whole cell was enlarged and the dentrites much swollen. The animals which began to recover were killed at varying intervals. Their neurons displayed various stages in the return to the normal structure. The opaque masses were slowly absorbed, and the tigroid substance was formed again.

The function of the neurons returned before the tigroid substance was replaced. This is in harmony with the view that the tigroid substance represents a store-house of potential energy, rather than an essential part of the cell structure, and that deutoplasmic granules may be of more complex molecular structure than the living proteid. According to Halliburton and Brodie, if an extract be made of the brains of animals dying from excessive heat, it does not produce a precipitate at 42° C. as do extracts of normal brains. The difference is clearly due to the fact that these have been precipitated before death, or at the time of death.

The globulins of muscles, glands, nerve cells and other active structures of the body give the first precipitate at about the same temperature. (It is commonly known that there are several globulins present in all living structures, some of which are only distinguishable by differences in their coagulibility.)

Mental Symptoms in Fever.

The significance of the mental symptoms observed in fever are easily explained in the light of these experiments. The temperature of the body cavities is certainly higher than the mouth temperature. The temperature within the brain must exceed the coagulation temperature of the tigroid substance before death. But a quite advanced degree of chromatolysis is not incompatible with ultimate recovery. Death, or permanent disability, is inevitable after the coagulation of the globulins which form an essential part of the cell structure. During very high temperatures, there is no mental activity whatever; under less increase of temperature, the mental activity is abnormal but intense. After recovery from high fever, the mental activity is decreased until the partly precipitated complex globulins representing the reserves of potential energy are again rebuilt by the cell.

In some cases, some of the cells may have yielded to the effects of the high temperature sooner than others, and these may have been injured in their essential structure. Recovery is not possible for these, and the patient never does recover his old measure of mental efficiency, unless embryonic cells may be developed to take the place of those injured.

Delirium is due to the stimulating action of the high temperature upon the neurons; torpor is due in part to exhaustion, in part to the presence of toxins, and, more seriously, in part to the partial precipitation of the deutoplasmic globulins in the neurons.

Fatigue.

The fatigue phenomena display two well marked series of disease symptoms. The symptoms commonly called fatigue are really conditions of poisoning from the retention of the waste products of metabolism. Very similar to this condition are the phenomena observed in the action of ferments. These act with celerity upon the class of substances to which they are adapted, but after certain changes are produced, the accumulation of the products of the ferment action hinders further action until these substances are removed. Cells are unable to maintain their normal metabolism in the presence of their own waste products, even though their food and oxygen supply remain normal, and every other factor is such as to facilitate metabolism.

The cells of more complexly organized beings are also unable to perform their functions normally in the presence of their own waste products. The more active the metabolism of any organ, the more rapidly are its waste products formed and the more esesntial is their rapid removal. The psychoses and neuroses which are usually considered due to exhaustion are in reality due more to auto-intoxication than to an actual exhaustion of the cells. It is true that there are conditions of real exhaustion underlying some of these neuroses, but by far the larger number of these are merely due to the retention of the wastes of metabolism within the system, or to some other form of poisoning, as, for example, the use of stimulating drugs.

The ordinary sensations of fatigue are due altogether to the accumulation of the katabolic products within the blood and lymph streams. Under normal conditions, there is rarely a possibility of exhaustion, in the literal sense of the word.

Exhaustion.

There are some instances, however, of true exhaustion, or of what seems to be true exhaustion. This occurs in the muscles as a result of long continued strain under excitement or the stress of some unusual circumstances. The muscle atrophies afterward, and only rarely recovers, though the maintenance of the normal nerve and blood supply seems to facilitate recovery in some cases.

In the case of the nerves, cases presenting the symptoms of exhaustion are more frequently found. In these cases, the rational treatment should include rest, and plentiful food, and the correction of all conditions which might interfere with the normal anabolic processes. In the cases mentioned in connection with fatigue, such a treatment would be disastrous. Here there is needed the increased elimination of the waste products, the rather slim diet, the increase of the oxygen supply, often the increase of exercise, and the correction of all factors which prevent the free elimination of the katabolic wastes. These cases present about the same subjective symptoms, but the treatment advised the one might be very inefficient for the other.

If any cell, or any organ of a complex body, does not perform its duties in a normal manner, it is because there is some reason for its mal-function. The use of certain stimulants may cause a further evolution of energy, and thus secure the appearance of the normal function, but this evolution of energy must be at the expense of the cell structure. The experiments which have been performed upon cells show this byond question, in the case of simpler animals, and there are post-mortem findings which verify the conclusion in human beings. The onset of starvation may be very greatly facilitated by increas ing abnormally, by stimulants, the activity of the organism subjected to experiment.

The fallacy of trying to increase the activity of over worked, poorly nourished structures by any form of stimulation, is apparent. It would be just as rational to try to stimulate an engine to run while the fire box is empty. In the other cases, where the fatigue symptoms are due to the accumulation of the wastes, an effort to secure a return to health by increased feeding would be as sensible as an effort to make a fire burn while the stove is full of ashes.

These considerations apply in a certain degree to the reactions of organs of the body to abnormal factors in their environment.

Among the simpler forms of life the injury or destruction of any organ is followed by the regeneration of the lost part. This process may be repeated for a number of times which varies for the species, but which has not been found unlimited for any. With the appearance of the complex and efficient nervous system such as vertebrates possess, the possibility of regeneration decreases. It has not yet disappeared, for even we ourselves grow new skin daily. For the most part, however, regeneration has been superseded by compensation. The nervous system has so perfectly unified the various and diverse organs of the body that the injury of one is shared by all, and the strength of one is shared by all. The nervous system regulates this matter very largely, though there are other factors concerned in compensation. The nerve relations concerned in compensation are discussed in Chapters VII and VIII.

BASIC PRINCIPLES.

The reaction of the body as a whole to its environment is for the most part a matter of conscious action. In the case of the unicellular organisms, we consider that certain phenomena are significant of life, and that the absence of these phenomena denotes death. So, in the case of people, there are certain mental attitudes which are characteristic of life, and there are certain other conditions which indicate the presence of some abnormality either of structure or environment. The normal person experiences pleasure in living. His circumstances may affect him unpleasantly at times,—he is not normal if he is able to enjoy, or to look with indifference upon any thing which occasions pain to any one, or which has a disastrous effect upon his neighbors in any way. Yet, on the whole, the normal person enjoys life, and likes to help others also to enjoy it.

A gloomy outlook indicates an abnormal condition of the cortical neurons. There are some diseases, notably tuberculosis, in which there is a tendency to an abnormal, because baseless, cheerfulness. The occurrence of this cheerfulness is not to be considered as indicative of a favorable prognosis in this disease, but if the dyspeptic should become cheerful the prognosis becomes bright almost at once.

Motion is characteristic of life. In the same way, expression is significant of the normal mental condition. The normal brain transfers the sensory impulses which reach it into some form of activity. The cell derives energy from its environment; it is not normal if it does not do so, or, if it does not use that energy for the good of itself and its race. The person of normal mentality derives energy from his environment and uses that energy for the good of himself and his race. He is not normal if he does not do so. The person whose cortical neurons are starved or poisoned is not capable of doing the best work, of living the best life, of attaining the highest pleasure, of enjoying or of expressing in any effectual degree those generous and altruistic instincts which make for the highest and finest development of human life.

In short, the person of normal brain works and enjoys work, lives and enjoys life, and bases all his efforts upon a rational appreciation of his environment, and of his own place in the midst of things. Mental conditions not in harmony with these factors are not normal and are significant of some interference with the structure or the nutrition of the neurons, or with the environment of the individual.

Note A.—According to Plato, "No man is voluntarily bad; but the bad becomes bad by reason of ill disposition of the body and bad education, things which are hateful to every man and happen to him against his will."

COLLATERAL READINGS.

Diffusion and Osmosis, in Howell's Physiology, p. 881, Edition of 1906.

The Assimilation and Synthesis of Fat, in Leathes' Problems of Animal Metabolism.

CHAPTER XIV.

ABNORMAL BODY FLUIDS MAY FEED MICRO-ORGANISMS AND PARASITES.

Co-ordinate Development of Host and Parasite.

These bodies of ours and the bodies of all other living things, plants and animals, parasites and all, have lived in a certain relationship for years which no one is able to number. During these ages beyond history, there have been many changes in the manner of life of these structures in answer to the changes in their environment.

Since these exert various effects upon the environment of one another, it is evident that a change in the metabolism of one group of organic life may affect the metabolism of other groups with which it is associated. Climatic conditions may affect one group, these in turn may affect some other group, and so on. Organisms subject to parasitic invasion may develop an armor of defense, or they may form substances toxic to the invaders. The parasites may in turn develop organs of defense, as the hooks of certain parasitic worms, or they may become immune to the toxins of their hosts. The hosts may become adapted to the presence of the bacteria whether they ever attempt to repel them or not. Symbiosis or helotism may result. The present metabolic conditions of our own bodies, as well as the metabolic conditions of the organisms which may become parasites upon them, are the results of this almost everlasting warfare between insistent guest and unwilling host.

STUDIES IN OSTEOPATHY.

"New" Infectious Diseases.

According to history, there have been many new forms of disease. It appears upon more careful search that the diseases recorded as new and intensely ferocious were really new only to certain nations or cities, and that their intense ferocity was due to great susceptibility of the people at that time. The ravages of the plague of the middle ages followed periods of want or of unusual climatic conditions. The damp weather facilitated the growth of various moulds upon the grains used as food; the poorer classes ate the diseased grain and became sick. They were thus subject to the attacks of bacterial diseases. Often they were half-starved during these years of poor crops, and were therefore more susceptible to disease. The bacteria which flourished among the very poor became thereby the more toxic and tenacious of life. Those whose lives were filled with luxury were rendered susceptible to bacterial invasion in part by their own ill habits, and in part by the increased virulence of the bacteria which were carried from the sick and starved of their poor neighbors. During the middle ages, the filthy habits of both rich and poor, in city and country, must have greatly increased the risk of infection, the susceptibility of all people, and the virulence of the infectious agent. The first appearance of any infectious disease finds almost any race extremely susceptible. On the other hand, infectious diseases are not likely to attain any great severity unless there is some factor which lessens the immunity of the race or the nation at that time. The history of plague among the Mongolians, of smallpox among the Indians, of leprosy in England and Scotland in the fifteenth and sixteenth centuries, of the times of plague in England in the seventeenth century, and of many bacterial diseases which savages of all races receive from their association with the civilized races, all seem to indicate the possibility of the development of racial immunity, or racial adaptation. At any rate, there is a form of racial and national immunity which is recognized by all writers on infectious diseases. (Note A.)

Through all the ages of progressive development, the cells of all complex bodies have been adapting themselves to the propinquity of such pathogenic factors as are present in their environment. The manner in which this adaptation is brought about is not known, but there are some facts of biology, chemistry and history which give a little light upon this really difficult problem.

Structure of the Living Molecule.

It is best first to consider the nature of the living molecule, which Verworn calls a "biogen." In this discussion the terms of "Ehrlich's Side-Chain Theory," as modified by several more recent investigators into the subject will be employed. It seems that the living proteid molecule, or biogen, is composed of a nucleus, or ring, of comparatively simple structure, to which are attached almost innumerable radicals, or side chains, which are concerned in the various reactions characteristic of the living cell. These side chains are of very various chemical forms. They may be of almost inconceivable complexity, or they may be so simple that their molecular form is known even now. They all agree only in being attached to the central nucleus, and in being in some manner under the control of that center. It is known that these side-chains include one or more radicals of a carbo-hydrate nature, one or more of the fatty acid series, besides the innumerable nitrogenous chains whose degradation products are broken down, built up, and in many ways rearranged to form sources of energy, of foods for growth or the end products of katabolism which are ultimately excreted from the body. The reaction of proteids and albumens have indicated something of the complexity of the side-chains.

Side-Chains.

Proteids which give the "biuret reaction" are known to contain the group, $(CO)^2$ $(NH^2)^2$. This is probably one of the common chains.

The xantho-proteic reaction characterizes the presence in the proteid molecule of the phenyl grouping. This is also one of the chains commonly found.

Miller's reagent gives a positive reaction in the presence of those proteids which contain the groupings of which tyrosine is the most familiar example.

Other chains are found almost universally present. Any discussion of the nature of these or of their cleavage products would require much more than the limits of this book. Many of these have been broken from the proteid molecule by the use of methods which display their molecular structure beyond doubt, and some of them have been synthesized in vitro.

The nature of the relation of the side-chains to each other and the central "ring"—if it be a ring—is as yet only a matter of conjecture, for the most part. It appears that the chains containing iron or sulphur in certain combinations are able to hold oxygen in a very unstable union, and to give it up to the oxidizable chains under certain metabolic conditions, such as are to be found in the muscle cells when stimulated by nerve impulses, for example. In this case, too, it is well known that after all the free oxygen has been abstracted from the muscle cells, the appropriate stimulation is followed by muscular contraction accompanied by the evolution of carbon dioxid. Oxygen, then, must be united with some of the side-chains.

The oxidizable substances or chains may be the carbo-hydrates or they may be other radicals. The form of the carbo-hydrate group (an aldehyde) and the character of the waste products resulting from muscle metabolism render it probable that in the case of muscles, at least, the oxidation of the carbo-hydrate chain forms the chief source of energy.

There are some of these chains which serve the purpose of attaching food radicals, and others which serve other ends. Many of these have been studied more or less thoroughly, but none have attracted more interest than the ones hypothetically considered functional in protecting the body from the evil effects of poisons, and in destroying bacteria. These side chains are a normal part of the living proteid molecule, according to Ehrlich and others, and are probably concerned in attaching the normal food radical to the biogen. When the side chains of the biogen have absolutely no affinity for the molecules of any given pioson, that cell enjoys absolute natural immunity from that poison.

This happens, apparently, in the case of some arachnids, which are able to endure enormous doses of tetanus toxin without any perceptible injury. Their blood does not neutralize the poison for some weeks, at any rate, for extracts from their bodies, or a few drops of their blood will induce the death of rats with tetanus symptoms for weeks after the last injection of the poison into the body of the spider.

Partial Immunity.

There are other conditions in which there is a form of immunity which is natural but not absolute. In these cases, the absence of appropriate receptors does not account for the phenomena observed. For example, Pfeffer's bacillus of influenza grows with difficulty upon any culture medium. Its best food is made of agar-agar upon which a drop of pigeon's blood has been spread. Now the pigeon is almost immune to influenza, yet its blood, in the slightly abnormal condition caused by being shed and brought into contact with the culture medium, offers the bacillus of influenza most excellent food. The pigeon owes its immunity to its phagocytes, according to Metchnikoff, and he bases his conclusion upon the facts just mentioned. It is not difficult to suppose that the changes occurring in blood under the abnormal conditions may affect its quality as a food for the bacillus. This is not remarkable, for in several instances compounds stereoisomeric with foods are of no value in the body, and other isomers of harmless substances are decidedly toxic.

The rabbit is perfectly immune to bovine pleuro-pneumonia, yet the best culture medium known for a long time for the bacterium of this disease was made of rabbit's blood and lymph. Rabbits can not be infected with the disease at all.

Instances of Partial Immunity.

In other instances, immunity is not perfect. This condition prevails among the human race and the higher animals in relation to many infectious disease. Ernst made a special study of bacillus ranicida, which causes a sickness among frogs. The disease is nearly always fatal in cool weather, but occasions very little discomfort in the summer. Ernst found that frogs kept in a temperature of 25° C. were almost or quite immune to the bacilli, while those kept at a temperature of 6° to 10° C. were always killed by the disease. The optimum temperature of the bacillus is 22° C., hence the immunity of the frog during the summer months is due to the increase of the frog's bacteriolytic powers during the warm weather.

Chickens are immune to anthrax ordinarily. Wagner shows that the anthrax bacilli grow well upon chicken blood serum at its optimum temperature of 42° C. If the temperature of chickens be reduced by making them stand in cold water, or if their resistance be lowered by the administration of chloral or antipyrin, their immunity fails and they fall victims to anthrax.

Acquired Immunity.

In all these cases, the immunity is natural, but is not absolute. Other forms of life, or these same forms under other conditions, display immunity after infection, and this immunity is called "acquired." The mechanism of this form of adaptation is probably somewhat as follows:

When the toxin penetrates the body which is not immune, and comes in contact with its cells, it enters into chemical combination with the side chains whose affinities permit such combination. These are variously affected by the presence of the abnormal radical. The metabolism of the whole cell may be seriously affected, or the side chain may be thrown off, in which case the cell more quickly recovers. It is characteristic of the biogen that it resembles the crystal in its power to replace, or to cause to be replaced, all of its lost parts, so long as its functional integrity remains unimpaired. The mechanism of the one action we understand as fully as we do that of the other. When the biogen has been affected by a removal of certain of its side chains, or when these have been injured, the side chain is replaced from the food materials in its environment. But the biogen outdoes the crystal, for when the biogen loses a chain in such a manner, if the poisonous substance remain present, it replaces not only the lost portion but it also forms others of like structure. These chains which are formed in excess are thrown off into the general circulation, and there enter into chemical union with the poisons. The biogens themselves are thus protected. This is the condition in "acquired immunity." In the investigations into this subject many laws have been recognized; the subject is not at all the simple matter that appears in this paragraph. There must be formed by the cell certain other chains, some of which are normal constituents of the cell while others are called into existence by the stimulation of the presence of the poisonous elements.

Ehrlich's Theory.

The chains of the cell which receive the poisonous elements are called by Ehrlich the "receptors". When these are formed in excess, as Wiegert supposes, Ehrlich calls them "amboceptors." These same bodies, the discarded chains which have an affinity for the poisonous groups, Metchnikoff calls "fixatives." These may differ in some respects when described by their investigators, but they are practically identical from the functional standpoint. There are other bodies which still further antagonize the various poisons and toxins, and which destroy bacteria. Ehrlich and his associates have studied chiefly the bacterial toxins.

Opsonins.

Wright and Mallory have studied the action of bodies which resemble Metchnikoff's fixatives, if they are not actually identical. These substances Wright calls "opsonins" from their function of preparing the bacteria for digestion by the phagocytes. The "opsonic index" of blood of various degrees of bacteriolytic power has been determined with care, and this index is made a basis for prognosis and treatment in certain instances. The opsonic index is raised in the presence of the micro-organisms for which the estimate is made. It is proposed to raise the opsonic index of the patient who suffers from certain infections by injecting into his own veins some of a sterilized extract from cultures of the pus of his own body. Whether this procedure will result in raising the opsonic index in a manner more advantageous to the patient than the cells in their unmodified reactions to the toxin can do, remains to be determined by future investigations. The results already attained have filled bacteriologists with varying degrees of enthusiasm, as is usual in such cases.

Absolute immunity can not fail. Diseases to which the race is absolutely immune are of no consequence to us, save as the study of all life increases our knowledge of all other life.

Partial immunity is a matter of very great moment. The human race is partially immune to all of the commonly recognized infectious diseases. This partial immunity is as good as absolute immunity under ordinarily normal conditions. Our own immunity fails, as does that of the animals and birds already mentioned, under conditions which render the metabolism of the body abnormal, or which injure the structural integrity of the body tissues. Immunity fails under the following conditions:

Failure of Immunity.

Injury of the epithelial cells may permit bacteria to gain entrance to the body cavities.

Any decrease in the numbers or activity of the phagocytes may permit the bacteria to remain in the body unharmed.

Abnormal katabolic products of abnormal cell metabolism may be harmless to bacteria, or they may even serve as food for them.

The bacteriolytic power of the blood serum may be decreased by decreased alkalinity. Since this depends upon the oxygen-carrying power of the blood, this decrease in immunity is often due to a deficiency of erythrocytes or hemoglobin.

The bacteriolytic powers of any of the living tissues may be decreased by the abnormal condition of metabolism. This occurs under the following conditions:

Those cells are most subject to infection whose nutrition is decreased. This is the case when the blood itself is poor, or when the arterial supply is deficient, or when the pressure of the blood within the vessels is decreased below the normal limits.

Those cells are subject to infection whose drainage is imperfect. This applies both to venous and lymphatic drainage. The accumulation of waste products in the neighborhood of the cell is one of the most potent causes of mal-function, and hence one of the most serious conditions in the presence of infection.

These cells are most subject to infection which are being subjected to irritating influences. The presence of dust in the lungs is a great aid to the bacillus of tuberculosis. Overwork of any cell group is also a cause of broken immunity.

Those cells are subject to infection which lack proper nerve connections. This is true of all tissues, and the failure of normal metabolism under such circumstances is the cause of the broken immunity.

Immunity seems to fail in the presence of great numbers of bacteria under conditions otherwise fairly normal. This statement is subject to much discussion. It is evident that clinical experience is not able to afford data sufficiently exact to settle this question, and experimental evidence of a satisfactory nature is wanting.

Note A.—"In but few of the islands of the Pacific have the aborigines been displaced by conflict of arms or by industrial competition. The great cause of their disappearance, during the earlier periods of intercourse was their inability to cope with the microbes of measles, smallpox, leprosy and other diseases, unknown to them before the arrival of the Europeans and Chinese."—Rev. John T. Gulick, in Publication 25, Carnegie Institution of Washington.

COLLATERAL READINGS.

General Theories of Bio-Chemical Action, in Schryver's Chemisty of the Albumens.

Resume of the Theories of Metchnikoff and Ehrlich upon immunity, in any recent work on general pathology.

CHAPTER XV.

THE HABIT OF DISEASE MAY PERPETUATE ABNORMAL CONDITIONS FOR A TIME.

When any organism becomes adapted to an environment which is foreign to its inheritance, it becomes thereby unable to respond in the normal manner, at once, if it is placed again in the surroundings originally normal to it. In the case of the simpler organisms a new environment very quickly becomes the normal one,—that is, the cell reacts quickly to external factors, and the series of chemical changes that are forced upon it in the stead of its normal metabolism succeed in a comparatively short time in impressing their rhythm upon the metabolism as a constant factor in the reaction of the cell to external changes. After this, the one time abnormal environment is the normal one for that cell. During the stage of progressive adaptation, the cell is not able to react in any logical manner to either the new or the old environment.

It is evident that the more complex is the organism undergoing adaptive changes, the longer will be the time spent in the formative, or unstable, or pathological condition.

Individuality of Cells.

Each of the cells of which the body is composed lives a life which is to a certain degree an independent one. It is true that they do depend upon one another, almost absolutely, so far as the maintenance of life is concerned, but it is also true that there is a certain individuality in the life processes of the various cells of the body; that they live, each in its own life; eat, each its own food; eliminate katabolic products, each of its own kind, and perform each its own duties. They react to their own environment, each for itself, though this environment is composed of the other cells of the body, and the fluids formed by them. Thus, the body acts as a unit, because the cells affect the environment of one another. Of all cells, the neurons affect the other cells in the most conspicuous manner.

Individuality of Reactions.

When any cell group of the body is subjected to the influence of abnormal conditions its metabolism undergoes certain changes, characteristic both of the cells themselves and of the nature and force of the abnormal influences. Every cell group gives its own characteristic reply to changes in its environment, both normal and abnormal. The connective tissues abnormally stimulated thicken and harden; the nerve cells act extravagantly, weary and die; epithelial cells multiply, and only become broken down in answer to the presence of insuperable obstacles to further metabolism. Muscle cells multiply with increased function; nerve cells never multiply after differentiation is well begun, long before birth. Many structures atrophy with disuse, but others may maintain a non-functional existence for years; in the case of the embryonic nerve cells, they may live undeveloped for a life time. In all these instances the principle holds true, that the reply which the cells of the body give to abnormal changes in their environment does not long remain that which is characteristic of their normal metabolism.

The Habit of Health is Persistent.

After a period of reactions to an abnormal development, the cells of the body do not at once regain their normal activity. There must needs be a second transition period, usually very much shorter than the first, during which the cells again accommodate themselves to environal changes. In some cases, recovery is much more tedious than the onset of the apparent disorder, but the period of apparent disorder is not always equal to the period of reaction to the abnormal environment. The habit of health retains at least a potential influence upon metabolism, even during long periods of disease.

Cells Retain History of Their Past.

The return to the normal function often seems perfect, but there is much more rarely a perfect, or even very nearly perfect, return to the normal structure. The cell usually retains in its structure the history of its unhappy experience. In this respect, the cells of the whole body share with the highly differentiated neurons the phenomenon of memory.

This principle holds true also for many very complex organisms, and for species of organisms. Plants and animals undergo certain changes as a result of domestication. If they escape from captivity and again lead a wild life, they regain many of their ancestral traits, but they never lose the acquired characteristics. The history of their captivity remains ineffaceably written in their bodies and in their habits.

This is true among mankind also. The Indian who, having been educated, returns to his ancient habits, is never the aboriginal person. The degenerate in civilized communities is never the savage. Atavism is never complete; recovery is probably never absolutely complete.

Habit and Prognosis.

These facts have an important bearing upon the prognosis in any case. If the patient has been suffering from a given disease for a long time, it is almost certainly true that the metabolism of the cells of the injured organ have made some steps toward adaptation to the abnormal condition, and that recovery will be complicated by the embarrassment of the cells in another adaptive process. The question will often arise as to whether it is wiser to subject the cells to this second adaptation, or whether it is wiser to let them alone in their new estate, and to facilitate the compensatory changes, by securing the best of food, air, nerve supply and elimination to the injured structures. There is no doubt that in dealing with old people, especially, the latter method is usually wisest. They have no time to spend in rearranging their physiology. They are to be made comfortable and as happy as possible. The number of years required to make a person old is not to be stated in this connection.

There are some cases among young people where the reaction of the body to an abnormal environment is so fixed that any effort at correction is unwise. The kyphosis of Pott's disease is a very common example of the deformity which is permanent and incurable, and not productive of serious visceral disturbance.

On the other hand, it must be remembered that the human body is one of tremendous complexity, and that a whole life time is not enough to secure any essential changes in metabolism. Adaptation more nearly normal than efforts at adjustment could be are not rare, but perfect adaptation to an abnormal environment is an accomplishment requiring many times one life time.

It must be remembered also that during the time in which the cells are in process of adjustment they endure the abnormal metabolism characteristic of the period of change. They are more intensely affected by external changes than are normal cells, more easily invaded by bacteria, more easily wearied, and enjoy less of the "habit of health" than normal cells.

Some instances of the persistency of the habit of disease may be mentioned.

Examples of Disease Habit.

After abnormal food is taken, vomiting may occur, which often persists after the stomach has been thoroughly emptied.

This vomiting may become a factor in perpetuating a diseased condition.

If anyone eats too much sweets or starches the excess of sugar is eliminated from the blood by the kidneys. If the habit of eating too much sugar be continued for any length of time, the physiogical glycosuria becomes a pathological one, and sugar continues to be excreted even after the carbohydrates have been eliminated from the diet altogether. This is a form of the persistence of a habit of abnormal function, for it must be granted that the presence of sugar in the blood in so great a quantity as to cause its elimnation by the kidneys is itself an abnormal condition.

Habit of Pain.

When sensory nerves are a long time subjected to abnormal pressure, as by tight shoes, or clothing, or by abnormally contracted muscles, they cease to seem painful. The removal of the pressure upon them, the relaxation of the abnormally contracted muscles, with the concomitant return to the normal conditions of blood supply and drainage, is frequently followed by much pain. Because of the habit of disease, the occurrence of the pain may be deferred for some time, and the careful physician may be able to evade much of the pain by making the recovery rather slow.

The persistence of pain is a very common occurrence. This is due to the lowering of the liminal value of the neurons concerned. If the neuron systems which carry sensations of pain are frequently stimulated, the continued passage of sensory impulses over them lowers their liminal value until even normal impulses arouse sensations of pain in consciousness.

This reaction is essentially physiological. The lowering of the liminal value of neurons which are frequently stimulated is a very important factor in perpetuating the habit of health, in preserving memories, in making possible such education as we know, and in adding to the value and strength of life in many other ways. But this factor in normal neuron metabolism becomes a means of perpetuating the consciousness of pain long after the cause of suffering has been eliminated. After the cause of the suffering has been eliminated, and the structure of the body becomes normal, the return to the normal neuron metabolism can not be very long delayed. The habit of pain is self-limiting, but it must always be considered in determining prognosis and therapeutics.

Habit of Drugs.

After a long illness which had been dealt with according to the strenuous methods of our grand-fathers, recovery was very long and difficult. Even yet, though the most severe methods have been superseded, recovery from the therapeutic methods seems to require more time and more discomfort than rcovery from the unaided disease. This is due, in part, to the fact that therapeutic procedures which are not wisely determined work rather injury than good, in part to the toxic action of the drugs employed upon the depuretic organs, and in part to the acquired habit of drugs.

The cells of the body, in reacting to the abnormal condition which was the original cause of the disease suffered certain changes in their metabolism. The doctor of ancient days added to this already complicated problem other abnormal factors,—various drugs, heat in an abnormal degree, impertinent stimulation of many kinds,—and the cells were compelled to adjust their metabolism to these factors also. The patients usually recovered, if they were young and robust. They were of the type that endures and survives hardships. During their enforced idleness, the overworked tissues became rsted, disorders due to trauma were apt to heal in spite of meddlesome attention, bones subject to slight subluxations regained their normal relations when the muscles attached to them became relaxed, the bacterial diseases were usually self-limited any way, and so recovery usually occurred in spite of the most absurd and harmful methods of therapeutics.

Readjustment.

After the subsidence of the symptoms due to the diseased conditions, the effects of the therapeutics were still to be overcome. The cells of the body had become partially adapted to the presence of stimulating drugs, the excessive heat, the close, dark room, and they had now to readjust themselves to the environment which was normal to them before the onset of the diseased condition. This second adaptation was forced upon the cells at a time when the blood was poor, their reserve forces were depleted, and the whole body was more or less permeated with both the toxins of the disease and the poisons used to combat the disease. It is not at all surprising that the accidents of convalescence were so often fatal, nor that morphinism, alcoholism, and other drug habits so frequently followed severe illnesses.

Osteopathic Methods.

In dealing with disease by osteopathic methods, the complications of recovery are very slight. The efforts of osteopathic therapeutics are to secure and to maintain, as far as possible, the conditions normal to the cells, and not to produce additional causes of confusion. If this be successfully done, long and tedious convalescence is usually avoided. The exceptions to this are found in the cases of chronic diseases which have been treated by abnormal methods for a long time, and in other cases associated with long and severe exhaustion. In all cases, recovery is not complicated by the necessity for a readjustment to the lack of abnormal stimulants.

As a matter of clinic experience, those patients whose recovery has not been complicated by any marked interference with the nature of the reply which the cell groups make to their environment are those whose recovery is most speedy, most comfortable, and least hampered by unexpected complications.

COLLATERAL READINGS.

Sequelae of any of the acute diseases, in any text book of medical practice. Decide which of the sequelae are probably due to the disease in itself, and which are due to the therapeutic methods employed.

CHAPTER XVI.

EXTERNAL CHANGES AFFECT ABNORMAL RATHER THAN NORMAL TISSUES.

It has long been accepted as an axiom that "a bad cold always settles in the weakest place," and that "fever always goes where there is sickness already." There are other sayings which have the same significance. Not all old sayings have a basis of truth; some of them have their only foundation in some tradition of witchcraft, yet others, such as these just mentioned, have a true principle underlying them.

Much that we are able to do for the relief of suffering would be of no value if normal tissues were affected equally with the abnormal. As a matter of clinical experience, we do affect the abnormal tissues without subjecting the normal to any interference with their activities. It is the function of this chapter to offer some explanation of the facts as noted.

Variations in Metabolism.

In the first place, the metabolism of the cells which are being subjected to abnormal influences is more or less variable in character. If any organism is placed under circumstances of unusual stress the series of chemical changes which make up its life history becomes very changeable in nature; the waste products of metabolism are not quite those characteristic of the same organism in health: the food stuffs taken up from its environment are not just the same as those used under normal conditions, and the whole quality of the metabolism becomes changed in the effort to adapt itself to the abnormal environment. In case of an organ of the body which is being affected by adverse influences, not only are the facts just mentioned true, but the function of the organ in the bodily economy varies in greater or less degree from that it serves in health. This erratic condition of the metabolism of the cells laboring under abnormal conditions renders them more subject to further disturbance from changes in the environment of the body than are the cells whose metabolism is a fairly stable result of an inheritance of some generations of practically unchanged surroundings.

Vascular Changes.

Another factor in this relationship is found in the quality of the walls of the blood vessels. These are somewhat elastic, besides being muscular, and are therefore subject to distension and relaxation as the result of changes in the blood pressure and in the action of the vaso-motor nerves. When the walls of any given group of blood vessels are relaxed, if the general blood pressure remains high, the capillary endothelium is subjected to a considerable strain. The formation of the nutrient lymph is thereby promoted to a certain variable degree. If the dilatation be increased to an abnormal degree, the phenomena of inflammation ensue. If the area affected include any of the mucus membranes of the body, the goblet cells increase in function, and, if the abnormal conditions persist, they increase in numbers also. If the dilatation is soon relieved, no permanent ill effects of the disorder are afterward recognizable. But if the dilatation should continue for a sufficient time, the muscles of the arterioles react to the strain, as both striated and non-striated muscles usually do, by becoming longer. This condition of the vessel wall is comparable to the condition of the gastric musculature in dilatation of the stomach.

There results, then, a dilatation of the blood vessels which is more or less permanent, according to the length of time during which the dilatation persists, the pressure to which the injured vessels were subjected, and the powers of recovery of the patient. This last factor is of no especial interest in this discussion. Now the tissues whose vessels have been dilated in some such a manner as that just described, must perform their work with a certain amount of difficulty; it may be that no abnormal symptoms result, because the organs of the body are able to perform their functions fairly well under considerable degrees of embarrassment; but if the handicap be too great, or if other injurious factors be active, the failure or mal-function of the tissues involved is apt to become very evident. It will be conceded that the organ whose vessels are even slightly permanently dilated is not to be considered a normal organ. These vessels are more subject to further dilatation than are normal vessels. Therefore, any sudden contraction of the vessels supplying another part of the body, or any sudden increase in the force of the heart's beat, exerts an ill effect upon them rather than upon the normal vessels. The tissues in the area of distribution of the affected vessels then suffer accordingly.

This slight permanent dilatation of the arterioles is present in the mucus membranes in the condition ordinarily called "catarrh." For a bad cold to "settle" in any part of the body is for the arterioles already somewhat weakened to become greatly dilated by a sudden rise in blood pressure. The effect of such dilatation is to induce the phenomena of inflammation, if these be not already present, or to increase them if they were already present. Every such additional dilatation weakens the vessels and renders recovery more difficult.

Segmental Reactions.

Another factor concerned in the comparative ease with which abnormal tissues are affected by external changes lies in the physiology of the nerve centers controlling the diseased organ. The metabolism of every organ or cell group in the body is regulated by a continual stream of nerve impulses passing from the central nervous system. Sensory impulses from any organ assist in the determination of the motor and secretory and vaso-motor impulses to that organ, and others related with it in structure or in function. "All structures innervated from the same segment of the spinal cord are affected by sensory impulses reaching that segment." Any diseased or injured organ sends a continual stream of unusual sensory impulses into the central nervous system; these may be sent into consciousness as sensations of pain or discomfort, or they may simply initiate reflex changes in the size of the vessels or in the activity of the diseased organs, of the other structures innervated from the same segment of the cord or from the same sub-cerebral area, or other tissues in relation with it.

The Neuron Threshold.

The repeated stimulation of any neuron or neuron system lowers its liminal value. The more frequently nerve impulses reach any nerve center the more easily it is stimulated, and the quicker and the more pronounced is its response to stimulation. The continual irritation of the nerve centers by the sensory impulses initiated from the abnormal structure or the abnormal metabolism of any organ lowers the neuron threshold or liminal value of these centers and renders them more easily affected by any stimulation than are the same centers under normal conditions.

It is evident, then, that if any series of impulses reach a certain segment of the cord, or any group of neurons, the structural relations being equal, the effect of this stimulation will be chiefly manifested by those neurons whose liminal value is lowest. So, if any center has been receiving an abnormal number of sensory impulses, as is usually the case with centers in relation with diseased organs, it is very greatly affected by comparatively slight stimulation. This effect is most apparent in those reflex actions which are of a segmental nature, or are apparently so.

Example of Segmental Reaction.

If any structure innervated from a given segment of the cord be diseased, the neurons which control that segment have a lower liminal value than other neurons of the same segment. This relation is of fundamental importance in determining the effects of certain therapeutic methods.

For example, that segment of the cord which gives origin to the eighth thoracic nerve sends fibers from its lateral horn which carry impulses to the sympathetic neurons which influence the size of the blood vessels in the stomach and pancreas, and affect the secretions of the gastric and pancreatic glands. This same segment of the cord also sends fibers from its anterior horn which terminate upon the striated inter-costal muscles. This segment of the cord co-ordinates the activity of other structures, not concerned in this illustration. If the articular surfaces of the eighth dorsal vertebra be irritated in any manner, sensory impulses will be sent into the cord and cephalad, and also reflex impulses will be sent out over the efferent paths which will affect either the stomach, the pancreas, or the intercostal muscles, according to the comparative liminal value of the neurons governing these structures. If the stomach be laboring with a mass of indigestible food, at the time of the irritation, the liminal value of the neuron system whose duty it is to co-ordinate the impulses concerned in gastric activity will probably be lower than the liminal value of the other neuron systems of the same segment. The stomach will then be more quickly and more urgently affected by the abnormal irritation than the other structures. The principle holds true for every segment of the cord and for every center in the medulla, pons and mid-brain, so far as their physiology in this respect has been investigated.

Effects of Fatigue.

This principle in its application to the nerve centers holds true only so long as the neurons concerned are active. After a certain time, which varies according to a large number of factors, the neurons whose liminal value has been abnormally lowered become fatigued. At first, the effect of fatigue is to lower the liminal value in still greater degree, so that stimuli almost negligible under normal conditions may at this time initiate excessive reactions. Afterwards, progressive degrees of fatigue and exhaustion lessen the power of the neuron to respond to stimulation until it becomes almost, if not quite, inert and functionless. During this period of decreased function on the part of the neurons innervating the diseased organs, its metabolism is affected less and less by external changes, and its own abnormality exerts less and less of an effect upon the other tissues of the body, by means of the nervous system. After this time, no compensatory action is possible through the intermediation of the central nervous system, and, on the other hand, no injury is offered the other organs of the body by means of the central nervous system. This loss of the nerve reactions may serve a useful purpose in many instances. It forces a rest of the abnormal organ which may facilitate recovery; it may prevent the injury of other organs, and it may save the patient from useless suffering during the last of his days.

Compensation for the lack of the functions of the diseased organ may be secured otherwise than by means of reflex action. This compensation is always something of a patch work affair, though it is much better than no adaptation at all.

Therapeutic methods owe much of their efficiency to the principle at the head of this chapter. If it be desired to increase the efficiency of the muscles of the dilated stomach, for example, it is possible to stimulate the tissues near the eighth dorsal spine and thus to initiate nerve impulses which will affect the stomach, or the spinal or inter-costal muscles.

Unfortunately for the development of a scientific and exact system of healing, but fortunately for the patients, this principle is a boon to the ignorant and careless practitioner; whether he be of never so rational a school. While the chances are about even as to whether he will help his patient or will injure him, he is not very apt to affect the normal tissues seriously unless he brings about some very severe structural changes. The apparent cures that frequently follow unintelligent manipulations are to be explained upon the basis of this principle. On the other hand, the very fact that abnormal tissues are more easily affected than normal renders the injury produced by unwise manipulations of the osteopathic centers in relation with the diseased organ decidedly disastrous, under certain circumstances.

The fact that the abnormal rather than the normal tissues innervated from the same segment of the cord are most affected by sensory impulses reaching that segment renders it possible for the skilled physician to affect almost any diseased organ in almost any manner he chooses, so long as the nerve centers are not exhausted. After this, he may secure the same end by indirect means, employing changes in general blood pressure, the activity of other organs, volitional impulses and other factors in securing either recovery, adaptation, or compensation.

Note A.—A familiar instance is found in an aching tooth. Every jar or unpleasant sensation increases the pain in the tooth. If one with toothache steps on a tack, the ache may be increased thereby. And every one knows how much longer the aching tooth is than its fellows.

CHAPTER XVII.

"LIFE IS SHORT, OPPORTUNITY FLEETING, JUDGMENT DIFFICULT, TREATMENT EASY, THOUGHT HARD; BUT TREATMENT AFTER THOUGHT IS PROPER AND PROFITABLE."—HIPPOCRATES.

This statement is as true as it is old. Hippocrates was contemporary with Plato and Socrates and Sappho and Demosthenes and all the other famous Greeks of the "Golden Age." But the teachings of Hippocrates made the first step toward osteopathy. Hippocrates was the first person who is known to consider medicine as a thing apart from superstition and priestcraft. He magnified the physical, mechanical aspect of the human body and its ills. Even to this day the value of "Hippocratic succussion" is recognized in physical diagnosis.

Treatment is Easy.

"Treatment is easy." There is nothing much easier than to make the average sick person feel better, or, rather, to make him think he feels better. It is true that temporary relief is often a very important matter; it is sometimes all that the most skilled and thoughtful person can hope to accomplish under certain circumstances. But temporary relief is not satisfactory to either patient or physician for very long. The normal environment of the normal person does not include a doctor, be he never so skillful. The doctor who keeps his patients may be a very successful person, considered as a business man, but this is not quite the best proof of the successful physician. The successful physician's patients seldom return except to bring their ailing friends. The exceptions to this rule are self-evident.

In any system of practice it is easy to do things which help the average person to some extent, at least tempororily. The average person recovers, any way, even with no help at all. Under the old system of drug giving, it was easy to prescribe some harmless thing which did not do much of anything, but made the patient feel better, partly because he knew somebody was trying to help him, partly because when the doctor was celled he stopped worrying about having to call him. If he knew that a bill of size and dignity awaited his recovery, that fact might have some effect upon the speed with which the mal-function disappeared.

Rational Therapeutics Rest Upon Rational Diagnosis.

"Judgment is difficult," becomes emphatically true when it is remembered that rational therapeutics must rest upon rational diagnosis. The term "diagnosis" has been often misused. Its literal significance is "to know through," or "to know thoroughly," and in that significance it must be used by the osteopath if he is to attain the full measure of his possible success.

By too many physicians of all schools of practice, diagnosis is held to be satisfactory if the disease of the patient be named. It is supposed that a certain entity, a disease, affects people, and that these certain, individual diseases can be driven from the body, or can be killed, etc. That is, by the ordinary practitioner as well as by the layman, diagnosis is considered satisfactory without any thought of etiology or pathology. This view is not at all satisfactory if diagnosis is to be used as a basis for the determination of therapeutics. Diagnosis must include, not only the naming of the symptom complex, but also the determination of the exact condition of the patient. Even when the name is determined, the descriptions of diseases given in the ordinary text books dealing with the nature and diagnosis of disease are almost worthless so far as giving any real knowledge of the condition of the patient is concerned.

Present Diagnosis Unsatisfactory.

The question, "What is the matter with him?" is very rarely answered in any satisfactory manner. It is true that our most careful study does not always permit a satisfactory answer to such a question as this, but it is also true that there is very little hope of our ever attaining any more satisfactory knowledge so long as we are satisfied with our present attainments. So long as our knowledge of the condition of the patient is unsatisfactory, so long will our therapeutic methods fail in doing the best thing for the patient.

Diagnosis and etiology are described with much detail in the textbooks of the older systems of medical practice. The amount of work that has been done in disentangling the knots and uneven webs in disordered metabolism is simply marvelous. Lives upon lives have been freely given in these investigations, and they have been profitable, in a way. But in the descriptions of diseases, after all this tremendous amount of work, etiology bears almost no relation to diagnosis or pathology, and none of these, apparently, bear any further relation to therapeutics than the fact that the naming of a disease renders a convenient index possible. If the name of any symptom complex referred to any well defined condition the present system might be defended. But this is not true.

The differential diagnosis is based upon the subjective symptoms, the history of the case, according to the statement of the patient and his friends, and the laws of averages. Possibly, the findings of some simple laboratory tests may be considered, or some methods of physical diagnosis may be suggested. The theories of averages and chances are very useful to the insurance man, no doubt, as well as to men in less respectable lines of business, but such considerations have absolutely no place whatever in professional life. If only one person in a thousand suffers from a certain group of symptoms, he suffers just as certainly as if the other nine hundred and ninety-nine were troubled in exactly the same manner. By the older schools of practice, it is still considered good diagnosis to name the disease, and good therapeutics to treat the disease.

Osteopathic Diagnosis.

If osteopathy differs in any respect from these irrational and unscientific methods it is in these respects, that it is good osteopathic diagnosis to know the condition of the patient from top to toe, and it is good osteopathic therapeutics to treat the patient who is in that condition.

The problems which each patient offers to the judgment of his physician are complicated by very many and very diverse factors. For this reason, the ultimate cause of any disease is often unrecognizable. In most cases the diseased condition of the patient who seeks a physician is not the manifestation of a single abnormal factor, but of a very complex series of coincident and successive factors. In many cases the symptoms of disease are the efforts at compensation or adaptation, and the efforts to combat these form one of the causes of further discomfort, if not of added embarrassment to the already injured body. Any abnormal condition of long standing, and many of those of apparently recent manifestation, must be considered as the resultant of many forces, some tending to a return to the normal function and structure, and some making for further injury or embarrassment. The judgment of the physician is at fault if he does not consider these predisposing factors as well as the exciting cause; the less noticeable elements of the complex of symptoms and laboratory findings, as well as the more evident manifestations of mal-function and suffering.

Illustration of Complexity of Disease.

As an illustration of these conditions, almost any disease might be cited. The common case of indigestion is useful in illustration because it is familiar to most people. If any one who is in good health becomes very weary, and at once eats a hearty meal, his digestion is very apt to be temporarily impaired. The indigestion is not due to the hearty meal alone, nor to the fatigue alone, but to the improper relation of these. A third factor often present in these cases, is the existence of a mal-alignment of the ribs, or vertebrae, or both, which causes an abnormal flow of nerve impulses to and from the spinal and bulbar centers concerned in digestion. The slight mal-function so induced is temporary if not subjected to unwise tampering. If the patient repeats his error, or if he forces himself to eat again before his stomach is ready for food, or if he adds to the abnormal condition by the use of various methods of dosing, flushing, fasting, stuffing, purging and whatnot, the condition may become chronic. The judgment which is difficult must recognize the effects of the abnormal therapeutics, as well as the effects of the original disorder.

Bacteria as a Determining Factor.

Again, the person who is weary, or is hungry, or is poorly nourished because of the faulty quality of his food, or is overfed, or whose habits of life have been abnormal, may be subjected to some bacterial invasion. His immunity is decreased by the abnormal conditions, and the bacteria are able to make themselves at home in his body, and to produce the symptoms characteristic of their presence. The specific disease that is produced is determined by the character of the organisms which gain entrance to his body, but the fact of invasion is determined by his bad habits, his deficient nourishment, his deficient elimination, or the structural mal-adjustments which interfere with the normal function of the tissues. The symptoms observed in such cases are not to be wisely interpreted without a consideration of the conditions which render the bacterial invasion possible. The presence of the bacteria or other parasite is merely an additional factor in the complex array of symptoms.

There are many examples indicative of the complexity of diseases usually considered the most simple. It is evident to one who gives independent thought to the study of disease conditions that almost every patient must be to a certain extent unique. He alone has just such a body as his own. He alone has lived just such a life as his own, he alone suffers just such structural mal-adjustments, such mal-function, and such symptoms.

"Judgment is difficult, thought hard; but treatment after thought is proper and profitable."

Given a thorough diagnosis, the best methods of treatment are fairly evident. The determination of the treatment best adapted to the requirements of the case is not difficult, and the prognosis is usually fairly evident. Prognosis must always be somewhat uncertain, since it rests upon certain possibilities of cell reactions which can not be determined by any methods of investigation with which we are familiar. But there are very many factors which modify the prognosis in any case which are subject to modern methods of investigation, and these are part of a rational diagnosis.

"Thought is Hard."

Rational therapeutics must rest absolutely upon rational diagnosis. If judgment and thought have been given, if the physician knows the condition of his patient as thoroughly as is possible under the conditions of the case, if he gives that "thought" which Hippocrates calls "hard," then the thing which is done for the patient is that which will bring his body into normal relationship with a normal environment, if this is possible; or will assist him to a symptomatic cure by securing adaptation or compensation; or which, recognizing the utter impossibility of any cure, will make his last days as comfortable as possible.

Because "judgment is difficult," because "thought is hard," "treatment after thought is proper and profitable."

The Future of the Race.

The thought of the physician must not be limited to the immediate good of his patient. So closely are all the individuals of civilized races bound together in mutual dependence, in a unity of thought and desire and endeavor, that the inheritance of future generations includes all of this generation's endeavor that is worth perpetuating, whether the devisers of any certain good leave children or not.

If a life be turned from weakness to strength, if brains be made normal and muscles be made strong, not only will that life be freer from pain and longer in years, but the world will have gained the fruits of the labor of those muscles and those brains, both in this generation and in all those which are coming. Even if the life of any patient seems of no particular value, the principle remains unchanged. The duty of the physician is to give to every person an opportunity to do his best possible work in the world.

The normal brain has the wider outlook, the truer logic, the clearer conception of the relations of things with each other and with the individual; the more normal brain gives the more normal answer to environal changes; the more truthful viewpoint leads to the more generous attitude, the deeds characteristic of the altruistic spirit. These are the things that live, because these are the things that are characteristic of health in such brains as ours.

The Responsibility of the Physician.

The responsibility of the physician is, then, first to his patient himself. To him he owes all that he can give which makes for thorough and permanent recovery. Next, he owes a duty to the world, that his patient shall be able to do his proper work therein. Then, he owes a duty to the future, that the descendants of his patient shall be worthy of life. Under certain conditions, it is the duty of the physician to conserve the best interests of the race by seeing that his patient is the last of his family. In other cases, reproduction should be encouraged. "Judgment is difficult" in no more superlative degree any where than in dealing with such considerations as these. These questions come to the doctor, and they are within his province.

Any system of therapeutics which neglects the consideration of these factors is not fit to survive. If it sacrifice the good of the race to the good of the individual in any sufficient manner, it will perish, ultimately, by the extirpation of its devotees. But if it sacrifice the good of the race to the good of the individual in only slight degree, it may persist almost indefinitely, perpetuating a race of people who are fairly normal, who live fairly well, who are fairly progressive, but who never reach the possibilities of strength, longevity, mentality, and helpfulness which should be within their reach. Perhaps it is not altogether unwarranted to say that such a condition is that of a very large proportion of people in the world today. Very few people are living up to their potential best, either physically or mentally, and there are very few deaths which are not made the more sorrowful because they are known to be premature.

STUDIES IN OSTEOPATHY.

The Doctor As Teacher.

The task which awaits the rational physician is no easy one. His judgments are difficult. We who have lived in the world have been taught that the doctor is a person who takes are aches and pains away. We believe that he can "cure" us. We know that there are certain laws that govern the rest of the universe, but we think these laws cease their action at the limits of our bodies. We smile at childish faith in rabbit's nests, new moons and four leaved clovers, then we solemnly take a spoonful every hour as per direction. We know our lives are abnormal, but we refuse to yield one tidbit of the leeks and onions while we expect our doctor to guide us safely through to the promised land of ease and rest.

We have been taught for ages that we were not expected to know any thing about the care of our bodies. It is a pleasant doctrine, and takes kindly to our self-esteem that we are not to blame for our ignorance, that ill health is innocent, that amidst a universe of law, our own bodies are subject to caprice and unreason.

The rational doctor must live up to the literal meaning of his degree, and become a teacher. He must see that the environment of every individual is such as is normal to one of his race and history. He must see that the environment of each organ of his patient's body is such as is best adapted to its best functioning. He must teach his patients such laws of life as they are able to comprehend. Above all, he must teach that nothing but rest, nothing but work, nothing but play, nothing but air, and food, and drink, can supply the place of these things. Nothing but good blood, freely moving, can supply the needs of any tissue of the body. None but normal nerves can guide the body wisely, and none but clean and well fed brains can serve as the organ of strong and rational and efficient thinking.

BASIC PRINCIPLES.

Note A.—According to Marcus Aurelius, "What is good for the bee is good for the hive." There is no field of human endeavor more productive of genuine good to the race than the effort to help people into clean, wholesome, rational, helpful lives. The person who wishes to give the most efficient aid to his fellow-man finds no finer opportunity than that afforded in the life of a physician.

COLLATERAL READINGS.

The Value of Laboratory Diagnosis, C. A. Whiting in the Report of the Third Annual Meeting of the Osteopathic Association of the State of California.

CHAPTER XVIII.

IRRATIONAL THERAPEUTICS MAY PERPETUATE DISEASE.

Reasons for Meddling of Nurses.

In the presence of suffering, it is a basic principle in human nature to desire urgently to do something to relieve the pain. This desire is based upon the physiology of the neurons of the basal ganglia. The incoming impulse which affects the basal ganglia in any way,—that is, which arouses any feelings or emotions,—at once seeks expression. It is the function of these collections of nerve cells to co-ordinate immediately the movements concerned in emotional reactions; so, when the feelings are aroused by any thing, the tendency is toward immediate expression. Now, when some member of the family is sick, the others, being grieved and sorry for the suffering, are placed in a condition of a certain temptation. They urgently desire to do something of advantage to the sick person, but even stronger than this most admirable endeavor is the unrocognized longing to do something to satisfy one's own feelings.

This desire is manifest, all unconsciously to themselves, in those who, in spite of their own evident lack of ability, insist upon nursing sick people themselves. Other fond relatives awaken the sick person "just to see if he is still able to know me." At root, this impulse toward helpfulness is one of the most praise-worthy of traits. It is praise-worthy because it makes for the persistence of the altruistic spirit, which secures the finest development of the race.

If the spirit of service, thus exemplified, fail in its endeavor, then it becomes rather a hindrance to progress in any proper sense. The poorly advised and fussy efforts of those who, not being guided by any more rational considerations than feelings, persist in satisfying themselves by performing unwelcome services and meddling with the natural progress of the disease toward recovery, are responsible for many long and weary days of hindered convalescence, and only too often for a shortened life. Doctors of every school recognize this mental condition of the patient's friends, and many are the placebos which are prescribed to the patient more for the sake of the officious friends than for the sake of the sufferer.

The whole tendency of the medical instruction given non-professional people in the past has been toward the maintenance of dense and hopeless ignorance concerning every function of the human frame. Partly because of this ignorance, with its related half-superstitious trust in the doctor because of his M. D., not because of his knowledge, partly because of a sort of undying faith in the ultimate total depravity of disease in all of its manifestations, and mostly because of this innate and irrational endeavor to do something, no matter what, the habit of meddlesomeness has become very firmly fixed in every body's ideas of propriety in the sick room. It is a foolish notion, but it cannot be at once eradicated from the minds of ignorant people, at any rate. The final elimination of the old priest idea in relation to the doctor's knowledge and powers, the education of the people until they are ready to believe that the laws of the universe are not set aside within their own bodies, and the wider recognition of the fundamental truths of biology and physiology will prepare the way for a rational habit of dealing with the sick,—a habit of considering no other factor than the good of the patient.

Irrational Therapeutics Are Harmful.

Therapeutic measures which are based upon the necessity for satisfying the desires of the patient and his friends that "all that can be done is being done" can never be truly rational. Such methods as are not absolutely indicated are harmful.

Irrational therapeutic measures injure the patient in three ways:—even if they be harmless in themselves they prevent the determination of the methods indicated, they are the occasion of considerable disturbance to the patient, who perhaps needs rest and quiet, and, more frequently, they are themselves a source of further mal-function.

The Harm of "Harmless Remedies."

Osteopaths find great difficulty, sometimes, in dealing with the kind and officious friends who have something "so simple, it could not possibly do any harm." It is needless to say that there is no power efficient for good which is not capable of harm if unwisely employed.

If one considers thoughtfully the therapeutic methods which are now discarded, and thinks of the number of lives which were shortened through bleeding, the over-feeding of typhoid patients, the denial of drink to the feverish, and all the list of the absurdities which are now left behind as barbarisms, he should find the lesson which is so often disregarded, that one should be rather sure that his measures are those adapted to the very condition of the very patient before he engages in any marked interference with the progress of the body itself in its efforts to accommodate itself to the conditions.

By far the larger number of cases which come to the osteopath present symptoms which are only in part due to the original cause of the mal-function; often the most severe and dangerous of his symptoms are the effects of the therapeutic methods which have been unwisely employed. A few cases, which probably duplicate others in the knowledge of most observant persons, may be cited in illustration of these points.

Examples of Irrational Methods.

The patient, always well, with an unfailing appetite and a habit of eating heartily three times every day, goes into a business which is rather confining. He keeps on eating as usual. One day he is more weary than usual, or he is worried about something. He eats some unusual dish, or perhaps more heartily than he is accustomed. He does not sleep very well, and suffers from nasea and head ache. There is some diarrhoea. He uses the ordinary "harmless" remedies for the diarrhoea. It stops suddenly. He eats rather heartily, from habit, though he is not hungry. He becomes feverish during the day, and takes some more "harmless" medicine,— purgatives, this time. He feels better, the next day, and eats enough to make up the time he did not lose while he felt poorly. He finds himself in need of purgative medicines very often, thereafter. The enema is suggested as being a "harmless" method of dealing with such troubles. He uses enemata and rectal dilators until the rectum has lost its normal tone. In the meantime, he has consulted all his friends, because he "does not like doctors."

In accordance with their advice, he tries a fast, tries full feeding, tries smoking, quits smoking for a week or two, takes all sorts of patent medicines, and finally goes to a doctor. Here he repeats, in slightly different manner, the history already given. He goes to other doctors, some of them rational, but he expects hasty cure, so loses confidence in a short time. His original indisposition was a very simple affair; if he had remained quiet for a little time, with no food, during the time of his nausea, perhaps there would have been no trouble afterwards. But the therapeutics were his undoing.

In case of accident, a slight wound is often irritated by the use of antiseptics of too great strength, and it is daubed with lotions or salves of reputed "healing" power, until the marvel is that healing ever does occur. Among ignorant people, salves are not infrequently kept in open jars, or perhaps with loosely fitting lids, from month to month, and these are opened freely in the presence of any sort of infection. It seems almost impossible to persuade people that there is no such thing in all nature as a "healing power" in any thing except the tissue which has been injured, and its neighboring fluids and tissues, and that the "healing power" of the injured tissue itself surpasses all that has been ascribed to any external application.

Education Eliminates Irrational Therapeutics.

It is the province of the doctors of this new time to begin to educate the people along the lines of common sense in their dealings with themselves. The process must be very slow, for the teaching of ages is not lightly set aside. The old type of doctor still maintains an attitude of pretension to something more than ordinary powers. It is perhaps more than half unconsciously maintained, as the result of the effect upon himself of the medical traditions. There are persons who honestly doubt the wisdom of giving a broader knowledge of physiological matters to non-professional people, because of the unwise instruction which has been given in times past. Education must proceed slowly, for many reasons. Sensible, intelligent people may be shown the reason for the methods of treatment described. They wrong their patients who give unrelated facts of pathology and disease symptoms, in their unattractive aspects, to people who know nothing of the wonderful and beautiful relations of health.

The reason for the simpler phenomena of every day experience, the reason for the instruction which is given in hygienic matters, the reason for cleanliness in the care of wounds, and, above all, the fact that health and sanity and power in life are not the result of mere whimsical chance, but that these things are the inevitable result of the normal body, well treated, and in its proper place in the midst of things, these things all people should know.

If these things might be understood by non-professional people, there would be less of carelessness among doctors, less of meddlesome fussiness among the friends of a patient, and the periods of convalescence would be quiet, restful, pleasant times of daily renewing strength.

CHAPTER XIX.

THERAPEUTICS MODIFY RACIAL DEVELOPMENT.

The possibility of the inheritance of acquired characteristics is as yet a matter of doubt. The term "inheritance" has been sadly misused in this connection, for many of the qualities popularly called inherited are merely acquired during gestation.

For example, the habitual use of morphine by the pregnant woman is followed by the birth of a baby morphine fiend. The habit is not inherited, it was acquired by the child during gestation. The child became addicted to the use of the drug just as the mother did, by being supplied with it daily. The effects of nutritive conditions before birth are not to be attributed to heredity, any more than are nutritive conditions after birth.

"The Hapsburg Lip."

The inheritance of acquired mutilations is apparently impossible, though deformities may be inherited, just as normal structure is. Peculiarities or deformities which render the individual less apt to marry, or less productive, are not perpetuated for many generations, unless there is very persistent inbreeding. The "Hapsburg Lip," for example, has been for sixteen generations persistent among the descendants of the Hapsburg House. It is shown very clearly in the pictures of the present King of Spain. This unattractive feature was not perpetuated deliberately, as a desirable trait, but it was an incidental factor in an inheritance which was perpetuated by the inbreeding consequent upon political marriages.

BASIC PRINCIPLES.

It is a matter of common knowledge that races and species are modified by changing environal conditions, but it is not easy to determine whether the facts as observed are due to the inheritance of acquired traits, or whether they are due to the persistence of those individuals in whom the traits which facilitate adaptation to the new environment are most prominent.

Without attempting to settle the vexed question, some factors concerned in it may be mentioned in connection with the discussion of the effects of therapeutic procedures upon racial development.

The fact of the unmodifiability of the structural hereditary substance is shown by the following facts:

Circumcision.

The Jews have practiced circumcision since Abraham's time, at least thirty-eight centuries ago. The necessity for the operation is as apparent among the Jews today as it is among the Gentiles.

Feet-Binding.

The practice of binding the feet of the high-born girls of China is of unknown antiquity. By this custom the feet are made a source of the most intense suffering for weeks and months, and then rendered useless for life. The binding is done in early childhood, before maternity is possible, yet after all these centuries of mutilation, the girl babies of China are born with normal feet.

Tattooing.

Among savage races, birth marks are almost unknown, though tattooing is very prevalent. Among different races, there are various habits of tattooing, sometimes of one sex alone, sometimes of both sexes, sometimes in childhood, sometimes in youth. The lack of birth marks is universal.

Galton's Law.

Galton's Law of Inheritance seems constant. According to this, if the hereditary substance of each individual be called one, the parents of that individual have given one-half, that is, each parent gives one-fourth; the grand-parents give one-fourth, that is, each grand-parent gives one-sixteenth; the great-grand-parents give one-eighth, that is, each grand-parent gives one-sixtyfourth part of the hereditary substance.

The generation preceding the great-grand-parents give, all together, one-sixteenth part of the hereditary substance, and so on. One-half plus one-fourth plus one-eighth plus one-sixteenth plus—— through all the past generations, equals one, or the amount of hereditary substance of the individual. This law seems constant, so far as structures are concerned. This includes the inheritance of mutations, variations, and deformities, but not acquired structural changes. It takes no account of acquired traits.

Since function exerts so great an influence upon structure, it would appear that the possibility of the inheritance of acquired function would necessitate the inheritance of acquired structural changes. That this is not invariably true is shown by the persistence of non-functional organs,—the pineal gland, for example, the ciliated epithelium of the acqueduct of Sylvius, etc.

Theory of the Inheritance of Acquired Characteristics.

Many of the different organs of the body are known to form certain ferment-like substances during their activity which facilitate the metabolism of like tissues all over the body. That is, the active muscle forms a ferment which facilitates muscle metabolism. The active gland forms a ferment which facilitates the metabolism of similar glands, and so on. These ferments are poured into the blood stream, and thus are brought in contact with all other tissues of the body.

While these ferments are especially adapted to the function of increasing the metabolism of tissues similar to those which produced them, they have also a certain effect upon all tissues which are engaged in metabolism.

Cells of organs or tissues which are stimulated to exhaustion do not form these ferments, or if they do form them, use them for their own metabolism. At any rate, the ferments are not thrown into the blood stream by exhausted tissues.

The germ cells are formed before birth. They lie dormant, but not dead, through intra-uterine life and childhood. At about the time of puberty, they begin to undergo more rapid metabolism, and the process of maturation begins. During all the reproductive life of an individual, some of the germ cells are undergoing the changes incident to maturation. The metabolism of the germ cells undergoing maturation is very intense.

The foregoing statements are the facts of the case, recognized by biologists. The theory is, in brief, as follows:

The Theory.

Since the germ cells are alive, even though dormant, during early life, it would seem that they might be affected, in some degree, by changes in their environment, that is, by changes in the character of the blood and lymph. Since metabolism is more intense during the period of maturation than in early life, the changes in the blood and lymph would exert the more profound effects at that time.

The ferments poured into the blood stream by the tissues functionally most active may be supposed to affect the metabolism of the germ cells, as they are known to affect the metabolism of other cells of the same body.

The ferment produced by any given tissue in its activity would induce a corresponding change in the metabolism of the germ cells in such a manner as to cause an increased efficiency of these parts of the hereditary substance which control muscular development. Or, the increased activity of nerve cells would produce ferments which would cause increased efficiency of those parts of the hereditary substance which control the development of the nervous system.

The individual resulting from the development of a germ cell from a parent whose muscular development was unusually fine would thus have certain possibilities of muscular development, greater than those possessed by the ordinary individual. The individual resulting from a parent whose nerve cells were unusually well developed would have certain possibilities of nerve development greater than those possessed by the ordinary individual.

If any parent uses any organ or cell group to absolute exhaustion, the ferments normally produced by the normal activity of that organ or cell group are lacking in the blood stream, and therefore in the effects upon the germ cells.

Inasmuch as metabolism is more intense during maturation, the effects of changing habits exerts most pronounced effects upon those germ cells which happen to be undergoing the process of maturation at that time.

These items account, in part, for the fact that children born of the same parents display such different characteristics, and that children often seem to lack those qualities in which their parents most excel. (Note A.)

Since the germ cells are affected by the nutritional conditions of the body in which they live, it is very probable that they are affected by the presence in the blood stream of abnormal substances which had been administered as a therapeutic procedure. It is not needful to accept the theory of the inheritance of acquired characteristics in order to recognize the effects of therapeutics upon racial development.

BASIC PRINCIPLES.

Hygienic Teachings.

Aside from hygienic teachings, such as the laws given by Moses governing matters pertaining to health, there was very little in the way of rational therapeutics until comparatively recent times. There have been rational teachers, "doctors," through all the ages, but their teachings have not met with wide acceptance unless they were associated with religious ceremonies. The condition of affairs was somewhat peculiar. The hygienic measures not associated with religious ceremonies were disregarded, and those which were associated with religious ceremonies were soon over laid with irrational formalism, and hedged about by restrictions which rendered the whole procedure absurdly inefficient from the hygienic standpoint. So long as they were obeyed, these hygienic teachings affected the development of the race only favorably, since those measures which make for the best development of the individual make also for the best development of the race.

Effects of Witchcraft.

The witchcraft idea has held control of therapeutics from ancient times even until the present. Under the influence of this superstition, the laws governing the development of other organisms were permitted to modify the development of the human race. Perhaps it might be said that intellectual development was hindered by the perpetuation of the witch idea in medicine, but this influence must have been of very little influence upon the whole. The acceptance of a wrong idea precludes any investigation into its truth, certainly, but it is probably true that the race accepted witchcraft because people were ignorant, rather than that they were ignorant because they used the witch idea in medicine. Under such conditions, the progress of the race was not affected either for good or for ill by therapeutic procedures. The strongest in body and the most aggressive in mind lived longest and with most pleasure, and left the greatest number of the most vigorous children. The weakly and feeble died early and left no children, or at most, only a few feeble offspring who soon perished. The early races fought their way to physical perfection through the same paths that are followed by plants and animals. They found no royal road to racial progress,—there is no royal road to racial progress.

A Few Old Ideas.

The first use of drugs was based upon the idea that Mother Nature had, hidden away somewhere, a certain specific for all the ills of human existence. She was supposed to have given hints as to their use, as children do in their play, by making the form or the color of the plant indicative of its function.

For example, people with bad livers are yellow; there is a plant with a yellow blossom and a flat, liver-shaped leaf; therefore, this plant is good for bad livers, and is called liverwort.

Another plant has a heart-shaped leaf; it is therefore good for cardiac disorders.

The mandrake has a root shaped like the human body. The childless woman sought carefully the root which most exactly resembled the child she desired, and was made fertile.

Bitter and nauseating doses were given in the hope of "driving out" the disease, as if there were a real thing in the body which should be treated.

A favorite method of dealing with hysteria rests upon a misconception of the nature of disease. The globus hystericus was supposed to be the womb which had traveled into the throat. So, they put musk, or other substance with a pleasant odor upon the lower part of the body, and assafoedita upon the chest and throat. The evil odor was supposed to drive the womb away from its abnormal position, and the pleasant odors were to attract it to its proper place.

The Reign of the Drugs.

After the days of the simples, and developing from these came the time of the really effective drugs,—drugs that influenced the functions of the body in strange and divers manners. These increased, decreased, and modified cell metabolism in a degree that now seems incompatible with life, to say nothing of health.

By means of this urgent dosing, one of two effects was secured,—either the patient died, and the natural forces looking to the extirpation of the unfit were accelerated, or they survived, and thus perpetuated their immunity to the drug employed. Those who were unusually susceptible to drugs died early in life. Those who were able to endure the strongest drugs in the largest doses survived longest, and left descendants who were even more adapted to the use of drugs than themselves. The drugs employed most frequently were of two classes,—purgatives and stimulants. To this acquired adaptation to purgatives we owe, in part, the tendency toward constipation which is so annoying a factor in the lives of so many people nowadays, and to the acquired adaptation to the use of stimulants we owe, in part, the tendency of the present generation to the use of alcohol, tobacco, etc. The toleration of our own race for stimulants far in excess of the toleration of any animal for them, and far in excess of the toleration of any of the savage races for them, is proof that our past habits of drugging have not been altogether fruitless. The craving for stimulants seems almost universal. If the habit of using alcohol is not present, its place is very often supplied by other abnormal stimulants, or, it sometimes happens that exciting contests, the "speed madness," affords the stimulant required. The present nerve racking speed of life, this turmoil of ceaseless competitive endeavor, this artificial and hysterical stress over unimportant matters, is not the product of the habits of this generation alone, it is the natural inheritance we have from the therapeutic procedures of our ancestors. "The children's teeth are set on edge."

The Persistence of the Normal.

The tendency toward toleration in the use of poisons was not so effective as it might have been for several reasons. The use of poisons was always abhorrent to the more normally minded among the people, and these, partly because of the strength which enabled them to resist the popular prejudice in favor of dosing, partly because of the lack of the drugs themselves, were rendered the more fit to persist in inheritance. This factor was the stronger in that the immediate effects of the drugs as given in olden times were very unpleasant.

The drugs were often very costly, and the doctors guarded the secrets of their prepartion with great care, so drugs and doctors were not freely employed in trivial disorders.

More potent, perhaps, than any of these factors is the habit of normal living, fixed in the cells of our bodies for generations not to be counted. The law is absolute, that those things which make for the highest and ultimate good of the race persist; but those things which affect racial characteristics adversely perish, and with them perish the structures displaying these traits.

Surgery and Evolution.

The effects of surgery upon racial development are probably not very profound. The facts already mentioned seem to prove beyond question the impossibility of the inheritance of acquired mutilations. It is true that by means of surgery the lives of the unfit may be rendered longer and more fertile, and that weakness may thus be perpetuated in a certain degree. It is also true that unwarranted surgical interference often shortens lives which may or may not be worthy of perpetuation. No doubt much gynecological surgery eliminates the possibility of conception unnecessarily. Many of these persons probably would have been barren, anyway, and those who were not barren by virtue of the disease which rendered the operation permissible are often unfit for maternity.

Those who die prematurely because of unwise surgery probably include some of those whose descendants would have been of value to the next generation, and some whose descendants would simply carry a little further the weaknesses which rendered the surgery permissible. The survivors of any surgical operation, whether wise or unwise, do not transmit any of the effects of the mutilation to their children. They may, however, be themselves poorly nourished and weak, because of a poor recovery from unwise surgery, and their children may be affected, directly or indirectly, by this mal-nutrition.

Considered in its broadest aspect, rational surgery must be considered a factor of value in the development of the race, while unwise surgery simply assists in the elimination of the unfit.

The Mental Aspect.

Any one who studies the family history of mental defectives and the insane must be profoundly impressed with the very large number of alcoholic, syphilitic and tubercular people among the ancestors of those unfortunates. Whether this is indicative of the inheritance of acquired characteristics, or whether the facts are to be explained by the supposition that the same instability is at the basis of all these conditions, is a question whose discussion is beyond the limits of such a volume as this. There yet awaits much experimentation and observation before the problem can be solved in any satisfactory manner. That a certain instability of the neurons is in the last analysis the cause of every mental, and of nearly, if not quite, every moral obliquity seems to be fairly well supported.

The family of the confirmed drunkard is placed at four generations, unless it is saved by frequent inter-marriages with families of unusual physique and right living. Even then, persistent alcoholism will extirpate any family in a very few generations, and its members will pass through various stages of hysteria, epilepsy, insanity and imbecility to extinction.

Given a certain instability of the neurons, and we may find, in one child, imbecility, in another, periodical alcoholic excesses, while another may seem even unusually bright until some urgent physical or mental stress initiates a complete break-down, and he becomes insane. Such as these, if they leave children, bequeath to them, not necessarily the disease from which they themselves suffer, but any of the other forms of manifestation of nervous instability. Any long continued disease, or especially unhygienic surroundings, or any severe mental or emotional stress lessens the powers of endurance, the forces of resistance, of the whole body. Since the neurons are normally the most highly specialized, and therefore the most unstable of all the cells of the body, they display in a most conspicuous manner the effects of constitutional weaknesses.

Note A.—If this theory be true, the maintenance of a normal life during the youth of the parents is essential to the health of the offspring.

Temporary goodness is not enough to provide for a good inheritance. The effects of a life of bad habits are not to be altogether or immediately evaded by sudden reformation. On the other hand, the effects of a good life are not lightly set aside, and the reformation does have its effect for good.

If this theory be true, the time for the beginning of the development of a human being should be well chosen. The time for the maturation of the germ cells is fairly well known, and for a somewhat longer period than that required for that process the health and nutrition of the parents should be above reproach. Pregnancy should never be permitted to begin during a time of fatigue, or of ill health from any cause whatever, or of any abnormal mental, or moral, or physical condition of either parent, nor for some weeks after a period of any form of mal-nutrition.

If this theory be true, it becomes possible for an individual to reclaim his own faulty inheritance for the sake of his children. It becomes possible for all who have children to hope to elevate the race in a perceptible degree, so that the next generation may have a better inheritance than our own.

On the other hand, it is an indelible tracing that is being written upon the structure of the cells which are to exist for all time to come. Somatic cells die, and their history dies with them, but the germ cells are as immortal as time, and their history affects the endless future. For even if the cells are so abnormal as themselves to die, the future of the race if affected by the absence of those who should have lived. The responsibility for the future of the race is not eliminated by the fact of childlessness.

If this theory be true, the attitude of the physician toward matters pertaining to reproduction, nutrition, and morality is a very important one. Such questions as these should be settled by people who have made a careful study of the matter. Doctors and teachers are the people from whom such instruction must come. These must instruct parents, chiefly, and through them, the children.

COLLATERAL READINGS.

Theories of Heredity, in E. B. Wilson's "The Cell in Its Development and Inheritance."

The Maturation of the Ovum, Ibid.

Spermatogenesis, Ibid.

CHAPTER XX.

THE TRUE OSTEOPATH IS THE TRUE PHYSICIAN. HE MUST BE THOROUGHLY PREPARED TO DO THE BEST THING POSSIBLE UNDER EVERY CONCEIVABLE CIRCUMSTANCE OF HUMAN SUFFERING.

This statement seems almost self-evident, and yet it is not thoroughly accepted in practice. If the theories upon which our practice is based are true, and it seems inconceivable that they could fail in verity, then it must include the treatment of all that can injure the normal body. There is no room for superstition, or priest-craft, or for pretence in sane, rational, helpful therapeutics.

Therapeutics Rest on Diagnosis.

Rational therapeutics can be based on nothing else than rational diagnosis. Given a thorough understanding of the real condition of the patient, the most satisfactory method of dealing with his case is almost evident.

People are sick, or they do not come to a doctor. If they are not sick in the way they suppose, the fact that they choose to appear sick is itself a symptom of some mal-function. So, it must be granted that they who seek the physician are always suffering from some abnormal condition. This abnormal condition must have a cause. There is no mal-function without adequate cause. This cause may be found in the structure of the body, or it may be in the environment, or it may be simply the persistence of a habit of disease. In any case, it must be granted that the existence of mal-function is absolute proof of some abnormal factor in structure or environment, or both.

The duty of the physician is to correct that which is perpetuating the mal-function, whatever it may be.

So, he must recognize the suffering. If he does not accept the fact that the patient is suffering, there is no right in his considering his case at all. He must recognize the suffering as present. He must determine the cause of the suffering. He may not be able to do this at once,—a thorough diagnosis is not to be made without time and care.

Having determined the nature of the disease, it is evident that it is the duty of the true physician to correct whatever is causing or perpetuating the disorder.

He may find that certain structural relations are at fault and that these may be corrected by his own fingers. It is clearly his duty to correct these structural conditions. These lesions may be the only cause of the disordered condition, and in such cases the "best thing possible" is the removal of the lesion and there will be a consequent absolute recovery. The manner of the removal of the lesion is a matter for study. This work also must be done in the "best possible manner."

No Royal Road to Skill.

Skill in the technique of doing things is the result of practice. Not only must one know how to do a thing, but he must be able to do it. This skill is not to be secured in any easy manner, but it must result from continual practice. With an accurate knowledge of the structure of the bones and their articulations, the muscles and connective tissues related with them, and the character of the abnormality present in any particular case, the best method of relieving the condition is manifest. The study of the clinic cases of various lesions and of the methods employed by others for their correction is of benefit, but the essential thing is the training of one's own muscles and sensory nerves. Muscles must be strong and trained to steady, efficient movements, fingers must be so sensitive as to seem almost possessed of brains of their own. This training comes not easily to any, though there are difference of natural bent and of previous training among persons. The continual training in the perception of touch, and in one's powers of making co-ordinated movements is the best possible method of securing ease and efficiency in technique. The key to skill in osteopathic technique is practice, and thought, and more practice.

Structural Changes.

In other cases, structural mal-adjustments are a predisposing cause of the mal-function, and a factor in perpetuating it. The exciting cause is frequently bacterial infection, over work, cold, or some other of the slightly abnormal conditions to which all people are sometimes subject, and from whose malignant effects the normal body is able to protect itself. In the presence of certain structural mal-adjustments, with their interference with circulation, innervation, nutrition or elimination, the cells of the body become unable to withstand temperature changes, over work, or bacterial infection, and abnormal conditions of metabolism result. The "best thing possible" in these cases is the removal of the structural mal-adjustment as quickly as possible, the use of such measures as secure their normal environment to the tissues most affected, the destruction of the bacteria surrounding the body, and such instruction in hygienic measures as are indicated by the habits of the individual.

Secondary Structural Changes.

There are other cases in which the structural mal-adjustment is the result of some acute disorder. There may have been some very unusual environal conditions to which the body was not adapted, and mal-function resulted. Disorders of digestion finally result from the use of improper food by the most nearly normal of people. The injury to the digestive tract thereby produced initiates abnormal sensory impulses to the centers in the spinal cord and the medulla which, in turn, cause motor impulses to the muscles of the back and neck. These relations have already been discussed in previous chapters of this book. This abnormal muscular tension is itself a source of other sensory impulses to the same and adjacent nerve centers.

By means of the unequal pull of these muscles, the vertebrae and ribs are held in slightly abnormal relationship,—not dislocated in the surgical sense, but held fixed in a position which they normally occupy only under certain very temporary conditions of movement. This slight, persistent, mal-adjustment is called a subluxation, or subdislocation, or bony lesion. It may be produced either by reflex muscular contraction, or by accident. The effects upon the function of the viscera innervated from the segment from which the abnormal structure is innervated are the same in both cases.

The "best thing possible" for the secondary lesion, as for the primary lesion, is to remove it as quickly as possible under the circumstances.

Adaptation the "Best Thing."

Sometimes structural abnormalities are fixed. Pott's disease is perhaps the most conspicuous example of this condition. Less noticeable instances come to light very frequently in practice. Abnormal tissue changes which have been a long time present cause adaptive changes in other tissues, so that what was in the beginning a source of injury becomes later a part of the normal condition. The condition is similar to that of the cells of simpler organisms, when they adapt themselves to an abnormal environment. The presence of abnormal structural relations never secures absolutely perfect adjustment, but it does secure an adjustment which is more nearly perfect than any thing which might be expected from an effort at correction.

It is often a very difficult matter to determine the extent of this adaptation. If the tissues of the body are becoming fairly well adapted to a certain deformity, "the best thing possible" is to let the deformity alone, and facilitate further adjustment, if necessary, by removing any conditions which render the process difficult. If the deformity is not arousing efficient efforts at adaptation, then its correction may be indicated. The line between the two conditions is not easily drawn. Only a very careful study of the condition of the patient and his history can settle the matter.

Symptomatic Recovery.

There are structural changes which are themselves incurable, but which may be met by efforts at compensation which result in a symptomatic cure. Absolute recovery depends upon the removal of the abnormal conditions. Symptomatic recovery may be secured by adaptation to abnormal conditions. This adaptation may be facilitated by securing those conditions which render the environment of the abnormal organs as nearly normal as possible.

Hypertrophy the "Best Thing."

The hypertrophy of the heart which follows valvular lesion is an instance of compensation. It may fail, yet the effort is toward a symptomatic cure. Hypertrophy is to be encouraged in such cases, by making the blood flowing through the vessels of the heart as pure, nutritious, and well oxygenated as possible, by removing every condition which interferes with the normal nerve impulses to and from the heart, by seeing that the blood pressure never rises above that which is normal to the heart during the period of its growth.

The removal of one kidney is normally followed by the hypertrophy of the other. Nothnagel's view of the mechanism of this process may be modified by the results of recent investigations as follows:

The destruction or removal of one kidney causes the dilatation of all the arterioles innervated from the twelfth thoracic segment of the cord, including the supra-renals. The dilatation of the supra-renal vessels increases the amount of their internal secretion in the blood stream. Thus is caused dilatation of the arterioles of the remaining kidney, with high arterial pressure. This condition causes both increased function of the remaining kidney, and an increased food supply thereto. Both of these factors encourage hypertrophy. In such a case as this, "the best thing possible" is to keep the purest possible blood, flowing at the highest possible speed, under the most nearly normal pressure, to the kidney, and to keep the path of the nerve impulses to and from the kidney as nearly unimpeded as possible.

In every instance of incurable injury compensation and hypertrophy are facilitated and hastened by the supply of good blood, normal blood pressure, free innervation, and such conditions of rest and temperature as are normal during the period of active growth of the organ whose function is being subjected to change.

With our modern conditions of abnormal living, many cases of disease are due to faulty surroundings and habits.

Instruction the "Best Thing."

For example, it may be that there is some faulty habit of eating which is causing, or helping to cause, the trouble. It must not be forgotten that the occurrence of one abnormal factor is no proof whatever that other factors instrumental in causing mal-function may not also be present. If dietetic errors be habitual, the physician must give the needful instructions plainly, in words adapted to the understanding of his patient. It is no compliment to a doctor for his patient to go to a grocery asking for "carbo-hydrates," because he has been told to eat them.

If other faulty habits are found to be causing ill health, or to threaten to cause ill health, it is the duty of the true physician to tell the patient about the matter. The utmost tact is needful in such cases, in dealing with some patients. Every patient, and every doctor, is a law unto himself in these matters, and the selection of the course of action which is "the best thing possible" is not always easy.

There is no subject concerned in the maintenance of a normal life, or in causing disease, or in lessening the strength and the value of life, which may not be discussed by the physician with his patient. It is the duty of every physician to know all that it is possible to know concerning whatever affects the mental, or moral, or physical well-being of his patients and the community, and to do all that he can to make life more sane, and rational, and strong wherever his influence may be felt.

The human body, and the life within that body, are wonderful and beautiful in health, and wonderful and pitiful in disease. Wise instruction in matters concerning the mysteries of life is gladly received by sensible, grown people, and if the matter is properly placed before fathers and mothers, they may be induced to see the wisdom of teaching the children in those matters which are so urgently important to them in their after lives.

Whether the physician choose to deal with educational matters or not, he should at least be prepared to give rational instruction to all who ask his advice.

Advice the "Best Thing."

The physician may find that his patient stands in need of the work of some specialist. The principle at the head of this chapter does not signify that the osteopath should be able to do the work himself which is needed in every case. Such an interpretation would be manifestly absurd. The best thing possible under certain circumstances is to send the patient to a dentist. It is not expected that the osteopath pull teeth. But he must know enough to refer the cause of persistent neuralgia to a toothache if it is the toothache that is causing the pain. "The best thing possible" under certain other circumstances may be the elimination of high heels from shoes, or a swaddling collar from the neck. The osteopath is not expected to be that kind of a surgeon, but he should be able to prescribe that kind of surgery when it is indicated.

Lenses the "Best Thing."

Under other circumstances, the best thing possible may be the fitting of appropriate lenses for the eyes. Some physicians of all schools, osteopaths among others, are able to do this work. There is no reason why many of them should not be prepared to prescribe lenses. There is no reason why they should do this work unless they can do it well. The thing they must do, if they are true physicians, is to determine whether the lenses are needed, or whether some other condition is causing the poor vision, or the "nervousness," or the headache, or whatnot. He must know enough to decide rationally whether his patient shall be sent to an oculist, or whether he shall be treated for a lesion in the ciliospinal center, or whether both procedures are indicated. In either event, he must know enough to determine whether the glasses are giving the desired relief, after his patient has worn them for a time, and in the other case, whether his own treatments at the cilio-spinal center are as effective as they should be.

Surgery the "Best Thing."

The same principles are concerned in major surgery. Not very many osteopaths are qualified to practice major surgery. In some states, they are not permitted to do so, even if they are qualified. In any event, surgery is a specialty. The surgeon must be only a surgeon, if he is to attain eminence. Now, the osteopath who knows his work well, must know when surgery is indicated, and when it is not indicated. He must be able to consult intelligently with the surgeon concerning the nature of the work he considers needful, and he must know whether the work has been properly done or not. In some places, such consultation would be out of the question, but this need not lessen the ability of the osteopath to determine the diagonsis, the need of surgical interference, and the prognosis.

In Alienism.

The same principle obtains in dealing with cases of alienism. It is for the physician to decide, often, whether the patient shall be sent to another place for proper care, or whether he himself can hope to assist him to normal conditions.

Such questions as these come to the practitioner daily. He must decide them fairly, upon the basis of such facts as he is able to secure. Having decided upon his decision after thorough consideration, he must be ready to bear the responsibility which he has assumed. His authority must be equal to his responsibility, and he must so accept it. His advice disregarded, his responsibility is at an end, but so long as his advice is heeded, he must consider himself responsible.

The measure of responsibility in such cases as these is very great for the young practitioner. But it need not be forgotten that opportunities for consultation are not lacking, that modern methods of diagnosis are very exhaustive, and that superhuman skill and wisdom are not to be attained by any one.

The chief difference between the experienced physician and the doctor with his diploma yet damp, is that the new graduate will be unable to make his diagnosis so quickly as his older colleague. With our modern methods of laboratory diagnosis, and our exact methods of physical diagnosis, and those methods of diagnosis which are almost exclusively osteopathic, the cases in which a mistaken diagnosis is justifiable are becoming very rare.

If the osteopath is the true physician, he will be thoroughly fitted to do the best thing possible under every conceivable circumstance of human suffering.

CHAPTER XXI.

THERE ARE CERTAIN POINTS UPON THE SURFACE OF THE BODY WHOSE MANIPULATION AFFECTS VISCERAL ACTIVITY.

Nerve Centers.

These points have been called "centers" for the functions regulated through their intervention. Physiologically, the term "center" is applied to a group of nerve cells wherein any function is regulated. The use of the same term in reference to points upon the surface of the body is not defended, but the term has become so well fixed in usage that it is perhaps better to continue its use than to add another term for the same thing.

These superficial centers are very closely related with the nerve centers, and owe their effectiveness to that relation. The nerve centers control the activity of certain organs by co-ordinating the nerve impulses received from the sensory nerves of those organs, from other tissues associated with these in structure or function, and from higher centers in the brain. The vaso-motor center, for example, is affected by sensory impulses from the heart, by sensory impulses from all over the body, by descending impulses from the basal ganglia, etc.

Regulation of Nerve Centers.

The nerve cells of these centers are affected by changes in their environment, as are other living cells. The respiratory center, for example, is stimulated by increasing venosity of the blood flowing through it; the heart center is affected in the same way. Both of these centers are subject also to the stream of sensory impulses which are continually being carried to them. All of the other nerve cells of the body are also affected by the quality of the blood flowing through them.

The nerve centers are affected continually by the nerve impulses reaching them from all other parts of the body in structural relationship with them. The action of the nerve centers, and therefore the action of the structures controlled by them, depends upon the character of the sensory impulses reaching the center. In other words, the action of any given center represents the algebraic sum of the nerve impulses reaching that center. If we wish to affect any function, then, we may do so if we can affect the character of the nerve impulses reaching the group of nerve cells controlling that function.

These groups of nerve cells are placed well within the nervous system, and inclosed in a bony case, hence any direct methods of affecting them are out of the question. The pathway of impulses from the center to the structure innervated may be directly affected in many cases, as, for example, in the case of the vagus and phrenic nerves, the cervical sympathetic ganglia, and others.

Since the nerve centers act in accordance with the algebraic sum of the impulses reaching them, it is possible for us to affect their action indirectly by changing the character of the impulses sent to them. This is done by means of appropriate manipulations of certain superficial areas called centers, also. Unfortunately, the term center, is thus applied both to the group of nerve cells and to the superficial area which is in closest functional relationship with it.

Demonstration of Superficial Centers.

These superficial centers were first recognized by clinical experience. Afterward, they were demonstrated by experiments upon animals and persons.

Clinical evidence has been somewhat inexact, as clinical evidence always must be, since patients nearly always suffer from so many and such complicated abnormal conditions. In cases of long standing every abnormal effect is itself a cause of other abnormal conditions, and these in turn result in yet other mal-functions, and so on. For this reason, the evidence afforded by observations upon patients has not been so satisfactory in isolating the individual centers as it has been in demonstrating the success of the therapeutic measures employed.

Areas of Hyperesthesia.

The existence of hyperesthetic areas and of abnormal muscular contractions in the neigborhood of the roots of the nerves supplying organs of disordered function was first a matter of clinical observation, and later a matter of experimental demonstration. In clinical experience, the relief of the muscular contractions and of the hyperesthesias was found to be followed by some relief of the symptoms noted. This relief was only temporary in some cases, but in acute disorders, and in cases wherein the muscular contraction was the chief factor in perpetuating the abnormal function, the relief secured by relieving the muscular tension and the hyperesthesia was permanent. These cases, whether acute or chronic, and whether the relief were temporary or permanent, proved the existence of a central relationship between superficial areas and viscera.

Subluxations.

It was also found that slight mal-positions of the ribs and vertebrae were usually found present in the neighborhood of the roots of the nerves supplying the affected organ. The osteopathic conception of the relation of slight mal-positions of bones and articular structures to the mal-function and disease of the various tissues of the body was thus determined. The fact that the correction of the mal-positions as found was followed by a decrease in the severity of the disease symptoms, and in many cases by either a symptomatic or an absolute recovery, established the relation of cause and effect beyond a reasonable doubt.

Physiology of Superficial Centers.

The existence of the osteopathic or superficial centers depends upon the fact that all structures innervated from any segment of the spinal cord are affected by all sensory impulses reaching that segment. Because of this physiological relationship, the viscero-sensory impulses initiate impulses to the skeletal muscles innervated from the same and adjoining segments of the cord, as well as to the viscera innervated from the same area. Conversely, sensory impulses from the skeletal muscles and other somatic structures initiate changes in the impulses governing the functions of the visceral muscles and glands, as well as the reflex actions usually recognized. This relation of the somato-visceral and the viscero-somatic reflexes underlies all the physiology of the osteopathic centers.

Structural Nerve Relations.

The anatomy of the nervous structures concerned in these reflexes is fairly well known. The axons of the sensory ganglia enter the spinal cord as its posterior roots. After the Y-division both branches of the axon give off collaterals which penetrate the gray matter and form synapses with the neurons of the anterior, lateral and posterior horns, and of Clarke's column. According to Barker, probably every axon sends collaterals to every region of the same, and probably also to every region of adjoining spinal segments. Thus the structure of the neurons is such as to facilitate the occurrence of both somato-visceral and viscero-somatic reflexes through every segment of the cord. (Note A.)

BASIC PRINCIPLES.

Somatic Reflexes.

The ordinary somatic segmental reflex actions are effected by impulses carried over the somato-sensory neurons either directly or by means of interpolated association neurons to the somato-motor cells of the anterior horns of the cord. The axons of these terminate upon the skeletal muscles.

Visceral Reflexes.

The ordinary segmental visceral reflex actions are effected by impulses carried by the viscero-sensory neurons either directly or by means of interpolated association neurons to the viscero-motor cells of the lateral horns of the cord. The axons of these cells terminate by forming synapses with the sympathetic neurons, and the axons of the sympathetic neurons terminate upon the visceral and vascular muscles, the glands, etc. The cells of the lateral horns send their axons outward chiefly with the anterior roots. It is these fibers which make up most of the white rami communicantes, the splanchnic nerves and the erigentes. The visceral portion of the third cranial nerve, the vagus, and those parts of other cranial nerves which are concerned in visceral activity arise from groups of nerve cells which are homologous with the lateral horn neurons, and, like the splanchnics, terminate around the cells of the peripheral sympathetic ganglia. According to Howell, there is probably only one relay between the viscero-motor center in the spinal cord or sub-cerebral centers, and the destination of the nerve impulse.

The viscero-somatic reflexes are effected by means of impulses carried by the viscero-sensory neurons either directly or by means of interpolated association neurons to the somato-motor neurons of the anterior horn, thence to the skeletal muscles.

The somato-visceral reflexes are effected by means of impulses carried by the somato-sensory neurons either directly or by means of interpolated association neurons to the lateral horns of the cord, thence to the sympathetic ganglia, and thence to the viscera.

These structural relationships are seen in slides from the various regions of the cord, medulla, pons, and mid-brain. The functional relationships indicated by these structures have been demonstrated by experiments upon animals and persons, as well as by observations upon sick people.

Superficial Centers in Diagnosis.

The superficial centers are of value in diagnosis, because the disorder of any visceral structure initiates a reflex muscular tension in the superficial center of that organ. Both the visceral disorder and the abnormal muscular tension produced by it are a source of increased nerve impulses to that segment of the cord. This abnormal increase of nerve stimulation lowers the threshold of the neurons concerned. Thereafter the receipt of normal impulses initiates extravagant reactions, both in consciousness and reflexly, because of the lowering of the neuron threshold. For this reason, the existence of marked muscular tension and of areas of increased sensitiveness along the origin of the nerves to any viscus is evidence of some abnormality of the structure or the function of that viscus.

Superficial Centers in Therapeutics.

In therapeutics, the same principle is concerned. Since the visceral activity may be affected by sensory impulses reaching the segment of the cord from which it is innervated, then it is evident that abnormal impulses from abnormal conditions of skin, muscle, articular surfaces, or other structures may exert an abnormal influence upon the visceral activities. This being true in any given instance, it follows that the removal of the cause of the abnormal sensory impulses, or the removal of that which interferes with the normal flow of sensory impulses, must exert a favorable effect upon the progress of the patient toward a normal condition, unless permanent structural changes have been caused by the persistence of the lesion.

The therapeutic procedures are indicated by the diagnosis and the etiology. Whether complete recovery will result from the removal of the original cause of the disease or not depends, it is evident, upon the nature and extent of the secondary changes which have been produced. In cases of structural mal-adjustment of long standing, certain changes occur in the gross structures, and also in the habits of metabolism of the cells which have been subjected to abnormal conditions of innervation. Absolute recovery, then, must be slow and uncertain. The symptoms may often be greatly relieved, in these cases, even when absolute recovery is impossible.

Palliative Measures.

In cases of acute illness, due to indiscretion, or to temporarily abnormal conditions of the environment, not associated with gross structural changes, it is sometimes possible

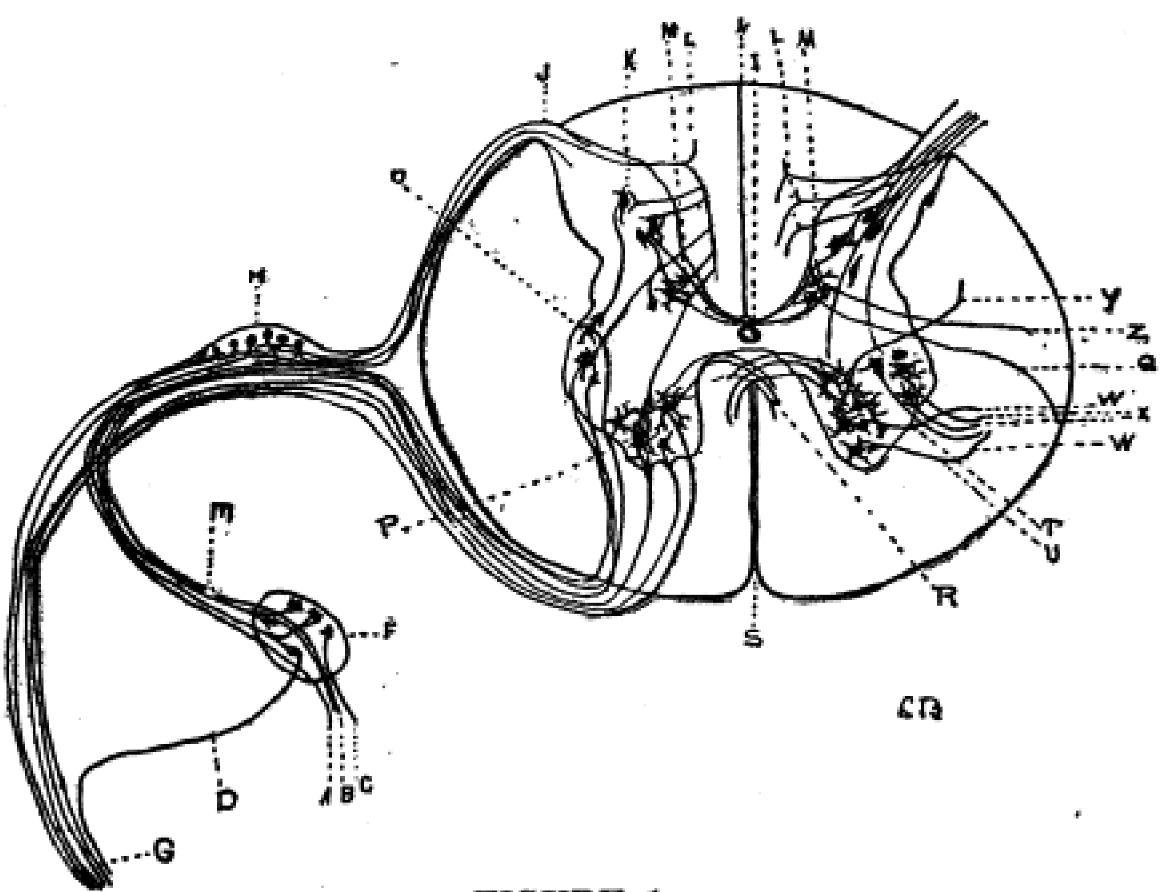

FIGURE 1.

to relieve the most annoying symptoms by manipulation of the center controlling the disturbed function. This is merely a palliative measure, but it is a very effective one whenever it is indicated by the condition of the patient. The efficiency of these measures depends upon the integrity of the neuron systems by means of which the reflex actions are effected.

Note A.—(Figure 1)—"The outlines of the cord and of the gray matter in it, and of the sensory and sympathetic ganglia, are drawn to scale. The size of the nerve cells is magnified and their arrangement is diagrammatic. It would be impossible to secure in a single slide all of these relationships.

"The fiber 'A' is viscero-sensory. The body of the cell is in the sensory ganglion 'H.' The peripheral prolongation, properly called a dendrite, is medullated. It passes through the sympathetic ganglion 'F,' without making any physiological connection with the sympathetic neurons, so far as known, and is distributed with the sympathetic nerves. These fibers retain their medullary sheaths until they reach the neighborhood of their termination in the viscera. 'B' is a viscero-motor fiber, the axon of a cell in the lateral horn 'O' of the spinal cord. These fibers form the greater part of the white rami communicantes, and they usually pass through one or more ganglia before forming a synapsis with sympathetic neurons. These fibers are medullated until they reach the ganglion of their termination. 'C' is a viscero-motor fiber, the axon of a cell in the sympathetic ganglion 'F.' These fibers are not medullated, usually, and the medullary sheath is extremely thin in the very few instances where it is found at all. Impulses carried over these fibers are derived from the lateral horn.

"The lateral horn of the spinal cord 'O' should be considered as part of the autonomic nervous system, of which the sympathetic nerves also are a part. The nerve cells of the lateral horn of the cord are smaller than those of the anterior horn, and the axons of these cells are finer. The axons terminate by forming synapses with sympatheic neurons. The cells of the lateral horn of the cord receive impulses from several sources,—from cells in the posterior horn 'K,' from cells of the spinal ganglion 'H,' by collaterals from their axons 'L,' from the red nucleus by way of the rubro-spinal tract 'X,' from the vasomotor and other centers in the medulla, and perhaps from other sources. Impulses are carried to the lateral horn only from sensory nerves and from centers which co-ordinate sensory impulses.

"Probably all the sensory nerves entering the cord send collaterals to the lateral horn of the same spinal segment. Normally, the sensory impulses carried to the cells of the lateral horn are just sufficient to initiate the viscero-motor impulses necessary to the normal action of the visceral and vascular muscles and the glands of the body. If these impulses are deficient,—as, for example, if the threshold values of the neurons concerned should be abnormally high,—the outgoing impulses are deficient. Any abnormal stimulation of the sensory nerves initiates abnormal stimulation of the cells in the lateral horn, and through these, of the sympathetic nerves. This abnormal stimulation may be received through viscero-sensory nerves as is the case in the presence of indigestible food, etc., or it may be derived from abnormally contracted muscles, from joint structures held in abnormal tension, as in subluxations, or, rarely, from the skin itself.

"Since collaterals from the sensory axons pass also to cells of the anterior horn, abnormal viscero-sensory impulses may initiate the abnormal contraction of the spinal muscles. This tension may in time bring about mal-position of the vertebrae. Both the muscular tension and the mal-position may in turn initiate abnormal sensory impulses which stimulate the cells of the lateral horn in an abnormal manner. This reflex muscular tension and the exaggeration of the viscero-motor impulses thus produced are of great value to the body under slightly abnormal conditions, but are a source of great misery if the visceral abnormality be continued. The effects produced from this long-continued muscular tension are probably not to be distinguished from those resulting from accidental structural mal-adjustments of long standing."—From "How Osteopathic Lesions Affect Eye Tissues," The Journal of The American Osteopathic Association, March, 1907.

COLLATERAL READINGS.

Sensory Visceral Areas, in Morat's "Physiology of the Nervous System," p. 154, Edition of 1906.

Chapter XXVII, in "The Nervous System," by L. F. Barker.

CHAPTER XXII.

THE EXPERIMENTAL DEMONSTRATION OF THE OSTEOPATHIC CENTERS; PRELIMINARY CONSIDERATIONS.

The experiments described in the succeeding chapters were performed upon animals and human beings. The subjects were young and healthy, for the most part; when old or unhealthy subjects were employed, the condition is noted in connection with the experiment. These experiments are not exhaustive; a great deal more work needs to be done before the possibilities of investigation in any of the lines here indicated are exhausted.

Anesthetization.

The animals used were anesthetized; they were not permitted to suffer, nor to regain consciousness after mutilation. Since these studies are essentially investigations into certain forms of reflex action, the experiments would be absolutely worthless if the animal were conscious of pain, or even if it were so frightened or uncomfortable as to struggle. Aside from any considerations of cruelty, then, it is very essential that no real discomfort be endured by the animals subjected to experiment. It is found that surgical anesthesia lessens the reflexes somewhat, but in many instances this had to be employed. Since the structures concerned are not changed by the anesthetic, but only the liminal value of the neurons, it is evident that whatever reactions are secured must indicate a structural relation of the nerves and centers concerned. On the other hand, if any reaction does not appear, it may be due either to the absence of such structural relations as render the reaction possible, or it may be due to the abnormal conditions of the experiment, or it may be due to the temporary physiological conditions of the neurons concerned in the reaction. For these reasons, no great significance is to be placed upon negative results, unless the experiment is repeated many times under varying conditions. It is probable that those reflexes which persist under anesthesia are those which are most persistent under other abnormal conditions. Ether, chloroform, cocoaine, morphine, and ether-alcohol were used to secure either complete or partial narcosis.

Subjects Employed.

Cats, dogs, guinea-pigs, frogs, toads and white rats were used in the series,—besides the human subjects. Cats, dogs, and white rats were most frequently used. All the reactions described were repeated many times, in order that the possibility of the effect secured being due to some individual peculiarity of the subject might be eliminated. Some of the reactions were repeated more than twenty times. Unless otherwise stated, each reaction was demonstrated upon at least five different subjects. Many reactions which seemed anomalous, or which were not found constant, are withheld from publication until they can be subjected to further investigation.

Elimination of Psychical Effects.

The human subjects employed were nearly all students of physiology. They were usually kept in ignorance of the nature of the expected reaction and the psychical factor was eliminated in every manner possible under the conditions of the experiment. The students who watched the reactions were often unaware of the location of the center which was being stimulated, and they simply noted, independently, the character of the changes which were occurring. In this manner, the psychical effect of expectation was largely eliminated. After each experiment, the human subject was not used again for several hours, in order that the after effects of one experiment night not possibly affect the next.

Sphygmomanometer.

The changes in blood pressure which were produced by the manipulation of the centers were measured, in the human subjects, by a modification of the Riva-Rocci apparatus. This sphygmomanometer was found very exact and delicate. It is recommended for the use of those who wish to criticise our results.

Sphygmograph.

Dudgeon's sphygmograph was used for the pulse tracings. It was secured upon the wrist and the normal tracing first taken. The clock work was stopped during the manipulations and started immediately after the work was finished. The sphygmograph was not removed from the wrist until the completion of the experiment. In this way any variations of positions, pressure, etc., were avoided. If the subject were lying down, he was first permitted to rest until all changes produced by the change of position had ceased to be manifested by the pulse. If he seemed at all weary, he was permitted to rest until no further change in pulse or blood pressure could be detected, before beginning the experiment.

Kymograph and Tambour.

The respiratory curves were taken with Marey's tambour. An extra tambour pan was placed over the apex beat of the heart, in order that the cardiac and respiratory waves might be represented upon a single curve. The needle of the tambour played upon a smoked paper upon the revolving drum of the kymograph. The speed of the kymograph was carefully regulated. The apparatus was not changed during the experiment. The curves as registered by these instruments were varnished and from these tracings the cuts used in illustrating the work were made.

Mosso's plethysmograph was used in the demonstration of the center controlling the circulation of the blood in the arm. This was connected with the tambour and tracings were taken, but these were lost. There has not been time to duplicate them for publication with the others.

Visceral Stimulation.

The direct stimulation of the viscera of animals was effected by means of electricity. A Du Bois-Raymond induction coil supplied the electrodes. The current was not measured, but was kept very weak. It was usually not perceptible to the touch, though sometimes it was increased. Pricking and pinching the viscera were found rather unsatisfactory unless the stimulation was applied directly to the interior of the viscus under experiment. The injury to the viscus necessitated by the direct application of the pricking to its interior was evaded by using electricity. The electrical current penetrates the walls of the viscera readily, and was found very satisfactory. The stimulation of the visceral walls by electricity is, of course, a condition never found in life, but the abnormal stimulation of the visceral walls by inflammation or by the presence of abnormal substances within the visceral cavities, or in the blood and lymph, is not unusual. The reactions produced by the electrical stimulation depend upon the existence of certain permeable pathways through the nervous system. The relations of the osteopathic centers must depend upon the existence of these same pathways.

Reflex Muscular Contraction.

The electrical stimulation of the viscera initiates the reflex contraction of certain somatic muscles. The persons who assisted in the experiments held their fingers along the back of the animal subject, and noted the contractions in the muscles as they occurred. The reflex contractions thus produced were recorded, and this information was held suggestive of the location of the center for the viscera being investigated. The stimulation of the centers thus located was found to affect the viscera in connection with them. The electrical stimulation of these centers was found of very little effect unless the electrodes were placed upon the deeper muscles or upon the joint surfaces. Stimulation of the joint surfaces initiated more urgent reflex visceral changes than did stimulation of any other structures. Stimulation of the skin over the centers was slightly effective in some instances. Inasmuch as the skin is normally subject to great variations of temperature and to irritation from many conditions, especially in the savage state, it is evident that no great visceral disturbance can be caused by stimulation of the skin, unless stimuli really injurious or very unusual should be employed.

Mechanical Stimulation and Inhibition.

Stimulating manipulations given with the fingers were found very effective in nearly all cases. These manipulations consisted of quick, vibrating movements, with the fingers between the transverse processes of the vertebrae. The movements were the more effective the deeper were the tissues stimulated. Vibration of the skin and superficial tissues was not very effective; stimulation of the deeper layers of muscles produced greater effects, while such movements as affected the articular surfaces were most effective of all. This stimulation affected the viscera in relation with the center in various manners, which are described in connection with the individual centers.

The Artificial Lesion.

Deep, steady pressure upon the same tissues caused an effect to be produced upon the viscera which was nearly always the reverse of that following stimulation in the same area. The pressure, or "inhibition" produced the greater effects the more the joint surfaces were affected. The effects of the "bony lesion" were secured by holding the vertebrae in positions of strain. This was usually done by placing the fingers of one hand on opposite sides of the vertebral spines and exerting as much pressure as possible. It is needless to say that this procedure requires both strength and skill on the part of the operator. In the accounts of the experiments given in the following chapters this maipulation is called, for the sake of brevity, the "artificial lesion." The effects of the artificial lesion are usually the same as the effects of inhibition in the same area, but under abnormal circumstances there are some differences in the nature of the effects produced by these manipulations.

The Aim of This Work.

The ends sought in planning these experiments were as follows: We hoped to demonstrate, in an undeniable manner, the structural and functional relations underlying the principles of osteopathic therapeutics and diagnosis.

We hoped to locate the osteopathic centers more exactly by eliminating the complexity of abnormalities which are almost invariably present in clinic cases.

We hoped to locate other centers whose recognition might aid in making osteopathic diagnosis more exact and osteopathic therapeutics more effective.

These ends have not been attained in as great a degree as is possible. The series is to be extended indefinitely. It is hoped that the publication of such results as have been attained will be of some value to students and physicians, both as indicative of the possibilities of experimental research and of careful clinical records, as well as a proof of the truth and the strength of the principles of osteopathic diagnosis and therapeutics.

BASIC PRINCIPLES.

Note A.—Some of the facts noted in the dissection of the many cats and dogs killed in these experiments may be suggestive.

Every pug dog killed was diseased. The fatter they were the more abnormal were the organs. The fattest dog I ever saw was one of these pugs. There was not a normal viscus in the whole body.

Dogs and cats which are sick enough to attract attention were always found diseased badly.

In the cases of sick animals, muscular contractions were found as often as tests were made for them. These areas of reflex muscular contraction were hypersensitive, also. After these "animal clinic examinations" as we called them, the animals were anesthetized and killed. The viscera affected were always those determined by the "clinic examinations." There were not so very many of these experiments, and hence many of the points involved in them are reserved for further investigations into the pathology of osteopathic centers.

Every animal condemned to death because of a bad temper, etc., was found diseased. The liver was the usual seat of disease for ill-tempered animals, both cats and dogs, but in several instances the brain was affected. In one case of extreme emaciation in a kitten the ovaries were found very cystic. Another kitten, apparently perfectly healthy, had cystic ovaries.

The diseases to which domestic animals are subject resemble those of their masters. The presence of tuberculosis among so many of them is a dangerous condition, especially where they are pets of children. Pets should be very carefully watched, and no considerations of sentiment should be permitted to prevent a painless death for the pet found diseased. Temporary sickness, as from over eating, may not be fatal, but the presence of a mastoid abscess, for example, with its drippings of infected pus, or the wheezing breath of tuberculosis, or any discharge from any of the orifices of the body, should indicate a very hasty and merciful execution. Persistent sore eyes and nasal catarrh should be held capital offenses.

CHAPTER XXIII.

THE EXPERIMENTAL DEMONSTRATION OF THE OSTEOPATHIC CENTERS: THE CRANIAL STRUCTURES.

Normal Innervation of the Cranial Vessels.

The blood vessels of the cranial structures receive their nerve impulses from a very complex arrangement of nerve centers in the floor of the fourth ventricle and the acqueduct of Sylvius, and in the spinal cord of the upper thoracic region. These centers are not described very clearly in the ordinary text books of physiology, and therefore a brief and simplified description of their relations will be given here for the sake of making the significance of the experimental work intelligible to those whose study of the relations of the cranial sympathetics has not been unusually thorough. It is not possible, within the limits of this volume, to give an exhaustive description of these relations.

A description of the manner in which the vessels of the nasal membrane receive their vaso-motor impulses will serve as an illustration of the innervation of the vessels of all the cranial structures.

The co-ordinating centers for the vascular innervation of these membranes, as for all other structures of the body which receive vaso-motor nerves, are affected by afferent impulses from the structures whose circulation they control, by impulses from other centers in structural and functional relationship with these, and by impulses from certain ganglia grouped around the base of the brain.

The sensory impulses carried over the olfactory nerve are of value chiefly because of the impulses which they send to the cerebral cortex, and the information thus given in consciousness. There is reason to believe that olfactory impulses do initiate some efferent impulses to the nasal mucous membrane, but these are not yet well understood. Their further discussion is of no immediate interest in this connection.

The fifth cranial nerve is the nerve of common sensation to the cranial structures. Since the nerves of common sensation are the ones which most efficiently carry impulses aroused by external changes to the vaso-motor centers, the fifth is the nerve chiefly concerned in the afferent side of the path of the nasal vaso-motor reflexes. Stimulation of the sensory endings of the nasal branch of the ophthalmic division of the fifth nerve by irritating gases or dust reaching the nasal mucous membrane causes an increased secretion of the nasal mucous glands and a congestion of the nasal membranes. The pathway traversed by the impulses concerned in this familiar reaction is shown in the following diagram (Figure 2).

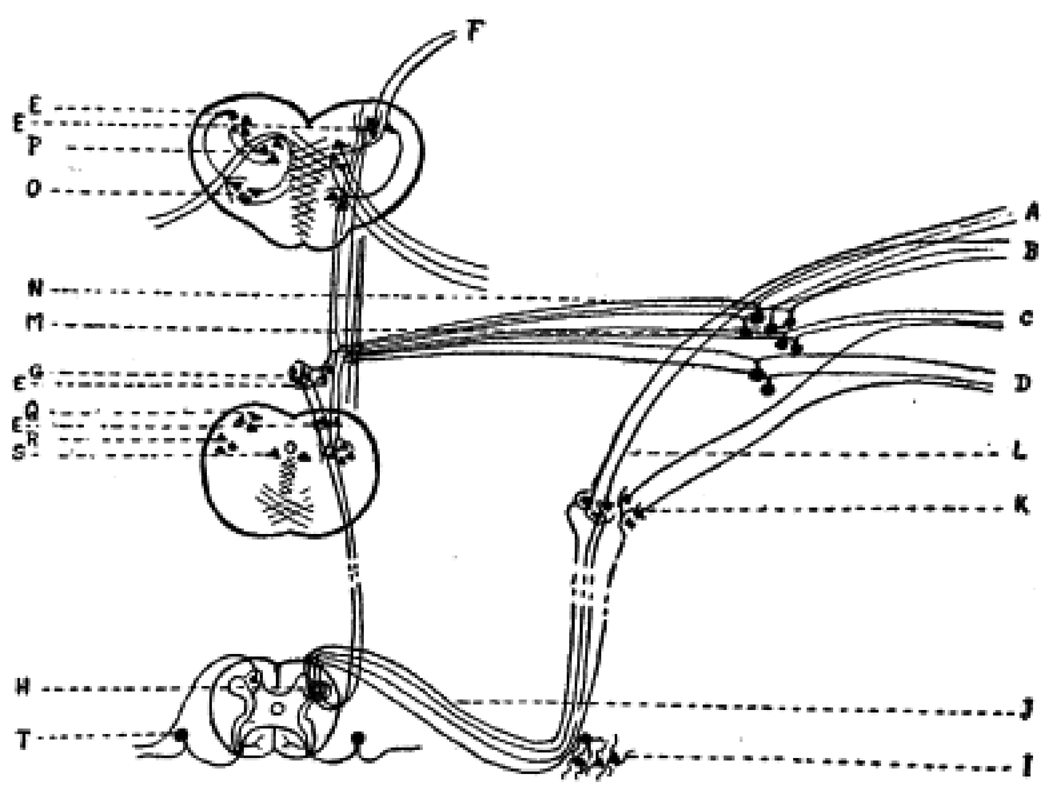

FIGURE 2.
A—Ophthalmic division of fifth nerve.

B—Nasal branch of ophthalmic.
C—Superior maxillary division of fifth nerve.
D—Mandibular division of fifth nerve.
E, E—Nucleus of insertion of fifth.
F—Fillet.
G—Vaso-motor center (location not exactly known).
H—Lateral horn of cord of second or third thoracic segment.
I—First or second thoracic sympathetic ganglion.
J—White ramus communicans.
K—Superior cervical ganglion.
L—Gray fibers from K to various branches of fifth nerve.
M—Gasserian ganglion.
N—Sensory axons from M to E.
O—Nucleus of origin of seventh nerve.
P—Nucleus of origin of sixth nerve.
Q—Nucleus gracilis.
R—Nucleus cuneatus.
S—Nucleus of twelfth nerve.
T—Sensory ganglion cell.

The sensory impulses arising from the stimulation of the nerve endings of the fifth are carried by way of the Gasserian ganglion, M, into the nucleus of insertion of the fifth, E, E, in the floor of the fourth ventricle. The nucleus of insertion of the fifth is a group of nerve cells which form a long, slender mass which underlies the whole length of the fourth ventricle. The entering axons of the fifth nerve, N, divide in a T-shaped manner, as do the axons of the spinal ganglia upon their entrance into the cord. Collaterals from these axons form synapses with nearly or quite all of the nuclei of the other cranial nerves, and with the cells of the various centers in the medulla and pons.

Some of the axons from this nucleus carry impulses by way of the fillet, F, to the optic thalmus, whence they are sent to the cerebral cortex, where consciousness is affected; other axons carry impulses to the vaso-motor center, G, in the lower triangle of the floor of the fourth ventricle. The exact location of the vaso-motor center is not known, but since the axons and collaterals from the nucleus of the fifth enter practically all areas of the gray matter at all levels within the bounds which are known to include the vaso-motor center, the relations are unquestionably as illustrated.

From the vaso-motor center impulses are carried by axons which pass downward through the lateral ground bundles of the spinal cord to the upper thoracic region. Here the axons which carry the impulses concerned in the regulation of the size of the vessels of the nasal mucous membrane plunge into the gray matter of the cord, and terminate by forming synapses with the neurons of the lateral horns in the second and third thoracic segment, H. The neurons of the lateral horns send their axons by way of the white rami communucantes, J, into the sympathetic system. The axons in which we are now interested do not enter into relations with the sympathetic ganglion cells until the superior cervical ganglion, K, is reached. The axons of the cells of the lateral horns which carry impulses for the control of the cranial sympathetics retain their medullary sheaths through the upper dorsal and cervical region until they reach the superior cervical ganglion. Here they break into fine fibrillae, which form networks around the bodies of the sympathetic neurons. The axons of the sympathetic neurons are not medullated. Those concerned in nasal vaso-motor impulses pass to the nasal branch of the ophthalmic division of the fifth nerve, and with it reach the vessels of the membranes whose sensory nerves were first stimulated.

It seems from the appearance of slides prepared in these laboratories that several cells of the sympathetic ganglia may be affected by one axon from the white ramus, and that more than one axon from the white ramus may affect a single sympathetic cell. This structural relation renders possible the very diffuse manner in which visceral reflexes are produced. (Figure 3.)

It must be plainly understood that the sympathetic system is not in any sense a complete system, but that it is merely a way station for the transmission and diffusion of impulses from the viscero-motor centers in the spinal cord, medulla, pons, and mid-brain. It must be understood, also, that none of these centers has any volition at all, but that every efferent nerve impulse is the inevitable result of the structural and functional relationships of the centers concerned in the reaction.

FIGURE 3.

Cells from the Thoracic Sympathetic Ganglia of the Cat.
1, 2, 3, 5 and 6 were stained by different haematoxylin methods.
4 and 7 were stained after the method of Nissl.
A—Axon from the sympathetic cell, arising from an axon hillock.
B—Axon from white ramus, breaking into fibrillae around the sympathetic neuron.
C—Remnant of the medullary sheath.

The dendrites of the sympathetic neurons and the fibrillae from the axons from the white ramus make a perfect rete mirabile. It is probably because of this marvelous complexity and the extreme tenuity of the fibrillae that the relationships here illustrated have not been described before.

Somatic Reflexes.

In the first series of experiments, the electrodes were placed upon the nasal mucous membrane ot animals under anesthesia. The muscles near the third thoracic vertebrae were at once strongly contracted. The latent period was very short in all reactions involving the cranial structures. The cervical muscles were somewhat contracted in more than half of the animals subjected to the tests.

The electrodes were then placed upon the conjunctivae. The muscles near the second vertebra were then contractd. There were also slight and inconstant contractions of the cervical muscles.

The electrodes were placed upon the eye ball. The muscular contractions were some times noted near the second thoracic vertebra, but the reaction was not constant. The cervical muscles were scarcely contracted at all.

The electrodes were placed upon the outer surface of the eye lids. The facial muscles were contracted very quickly and forcibly, but no contraction of the muscles of the upper dorsal region was noted.

The electrodes were placed upon the tongue, the inner surface of the cheeks, and the roof of the mouth. The facial muscles were quickly contracted, and reflex muscular contractions were noted near the third thoracic spine.

The electrodes were placed upon the tonsils. The reflex muscular contractions appeared near the third and fourth thoracic spines.

The electrodes were placed within the pharynx. Muscular contractions appeared near the third thoracic spine.

The throat was exposed to view, and the electrodes placed upon the vocal cords. The cervical muscles were very strongly contracted, as were also the spinal muscles of the fourth and fifth thoracic segments. The first and second intercostals were also strongly contracted.

The trachea was opened and the electrodes placed upon its inner surface. The scaleni and the sterno-cleido-mastoids were very strongly contracted. The first and second intercostals, and nearly all of the inter-scapular muscles were also contracted.

The electrodes were placed upon the thyroid glands, and the reflex muscular contractions appeared near the second and third thoracic spines. The contractions initiated by the stimulation of the thyroids were not very strong, but were constant. The deeper cervical muscles were always involved in the reflex action caused by the stimulation of the thyroids.

The skull was opened and the electrodes placed upon various portions of the meninges. The facial muscles were contracted in all instances, and the cervical muscles were often contracted also. The upper dorsal muscles were not often contracted unless the brain itself were stimulated. In this case, the effects of the stimulation depended upon the area of the cerebral cortex affected.

Superior Cervical Ganglion.

The superior cervical ganglion was exposed to view, and the electrodes placed upon it. The pupils became greatly dilated, the conjunctivae became lighter in color, and the mucous membranes of the nose and throat were also lightened. The superior root of the superior cervical ganglion was cut. The direct stimulation of the ganglion produced no effects. The sympathetic chain was cut below the superior cervical ganglion. Direct stimulation of the ganglion produced the same effects as before. Therefore the pressure of abnormally contracted cervical muscles upon the superior cervical ganglion may exert an evil effect upon the cranial structures which receive their innervation by way of these ganglia.

After Section of the Sympathetic.

After section of the sympathetic chain, stimulation of the cranial structures did not produce any effect upon their blood vessels, except such as might be referred to the direct influence of the electricity upon the vessels' walls. Therefore, the impulses concerned in this reflex action pass upward through the cervical sympathetic chain.

The muscles in the upper dorsal region were contracted by the stimulation of the cranial structures, just as before the section of the sympathetic chain. Therefore, the sensory impulses which are concerned in the reflex contraction of the upper dorsal muscles do not pass downward through the sympathetic chain.

The Gasserion Ganglion.

The Gasserion ganglion was exposed to view. The ganglion was stimulated directly. The upper thoracic muscles were very strongly contracted, and the blood vessels in the area of the distribution of the fifth nerve were immediately and strongly contracted. Some of the sympathetic fibers are carried by way of the fifth nerve. In order to exclude the effect of the direct stimulation of these fibers, the fifth nerve was cut, and the central end was stimulated by the electrodes. The muscles of the upper thoracic region were contracted, as before. The vessels in the area of distribution of the fifth nerve were contracted after latent period of a minute or so.

Extirpation of the Gasserion Ganglion.

The Gasserion ganglion could be extirpated in some animals without perceptible injury to the sympathetic fibers from the superior cervical ganglion. This must have been due to some peculiarity of distribution of the sympathetic fibers. The operation was considered to be successful when the direct stimulation of the upper thoracic sympathetic cord produced effects upon the pupils and the blood vessels of the mucous membranes of cranial structures. In some animals, the sympathetic fibers are so closely connected with the fifth cranial nerve that the extirpation of the ganglion prevents all passage of nerve impulses from the cervical or upper thoracic ganglia to the cranial structures.

The tests made upon the animals in whom the extirpation of the Gasserion ganglion was possible without injury to the sympathetic fibers will be considered at this time.

After this operation, the stimulation of the cranial structures did not produce any perceptible effects upon the vessels of the tissues stimulated, or their neighbors, except such effects as might be attributed to the direct effects of the electricity upon the vessel walls. The stimulation of the fifth nerve did not produce any contraction of the muscles in the upper thoracic region after this operation.

The stimulation of the central end of the injured nerve caused strong muscular contractions in the upper thoracic region, and also constriction of the vessels in the area of distribution of the fifth. Direct stimulation of the superior cervical ganglion produced effects identical with those produced before the mutilation.

The spinal cord was cut above and below the superior cervical ganglion. This cut was made from behind, and the sympathetic chain was uninjured. The effects noted after both operations were the same, and can be described as one.

The stimulation of any cranial structure failed to cause reflex contraction of the muscles in the upper dorsal or the cervical region.

Stimulation of the cranial structures did not produce any vascular changes except those which might be referred to the direct effects of the electricity upon the vessel walls.

Direct stimulation of the superior ganglion produced the effects noted before mutilation.

Therefore, the cervical portion of the spinal cord is an essential element of the reflex arc by way of which sensory impulses from the cranial structures are able to effect the condition of the upper dorsal muscles, and also in the path by which these impulses are able to affect the size of the blood vessels of the cranial structures themselves.

Cranial Somato-Visceral Reflexes.

The relations demonstrated in the series of experiments just described were held to be suggestive of certain possibilities of somato-visceral reflexes.

Mechanical stimulation of the tissues near the second thoracic spine was followed by a contraction of the blood vessels of the cranial mucous membranes and the conjunctivae, by a dilatation of the pupils, and an increased secretion of saliva. These effects were practically invariable.

The artificial lesion affecting the tissues near the second thoracic vertebra produced a dilatation of the blood vessels which was most marked in the conjunctivae, but which affected the other cranial membranes to some extent.

Stimulation of the tissues near the third thoracic vertebra was followed by a constriction of the vessels of the nasal mucous membranes and the pharynx. The effects upon the conjunctivae were less conspicuous.

The artificial lesion affecting this vertebra caused a slight rather general congestion of the cranial membranes.

Stimulation of the cervical tissues did not produce any effects upon the cranial structures unless the stimulation was so pronounced that the cervical sympathetic chain or ganglia were directly affected.

Stimulation of the muscles in the cervical region affected the sympathetic structures very easily, hence, the existence of abnormally contracted muscles in the cervical region is a menace to the normal activity of the cranial sympathetics.

The artificial lesion affecting the cervical vertebrae caused contractions of the cervical muscles rather readily. In the lower spinal areas the artificial lesion affected the spinal muscles only slightly, within the time occupied by our experiments, but the cervical muscles become contracted within a few minutes after the artificial lesion was produced. The latent period for all cervical and cranial structures is comparatively very short.

The superior cervical ganglion was subjected to mechanical stimulation by the manipulation of the tissues over it. In animals, this maneuver was followed by dilatation of the pupils, and by a contraction of the cranial vessels, which was soon followed, if the stimulation was continued, by a dilatation which was rather persistent.

Extirpation of the Gasserion Ganglion.

After the extirpation of the Gasserion ganglion without the injury of the sympathetic nerves, the mechanical stimulation of the tissues near the second and third thoracic vertebrae caused the same vaso-constriction and pupilo-dilation as was observed in the animal before mutilation.

After the destruction of the cervical portion of the sympathetic chain, and after the extirpation of the Gasserion ganglion in most animals, the mechanical stimulation of the tissues in the upper dorsal region did not produce any perceptible effects.

Destruction of the Cervical Cord.

After the destruction of the cervical portion of the spinal cord, stimulating movements in the upper dorsal region produced the same effects upon the blood vessels and the pupils as did the same movements before mutilation. In some instances, the reactions were increased after the destruction of the cord, as was to be expected. It was not possible to make quantitative tests of these reactions, under the conditions of our experiments.

Experiments Upon Human Subjects.

A series of experiments were performed upon human beings. Irritation of the skin over the back of the neck caused temporary dilatation of the pupils. The most conspicuous results were secured when the irritation (a brush was used) was applied to the skin over the seventh cervical to the second thoracic spines.

Mechanical stimulation of the tissues near the second and third thoracic spines caused dilatation of the pupils and contraction of the vessels of the cranial mucous membranes.

Inhibition, or the maintenance of an artificial lesion, caused dilatation of the vessels of the nasal mucous membranes and of the conjunctivae. The eye ball was also somewhat congested. The pupils were dilated in this case also.

The superior cervical ganglion is subject to direct stimulation in most persons. The fingers were firmly placed over the ganglion, and the deep vibrating movements given. In some cases, the electrodes were firmly pressed over the ganglia, one on either side. The effects of this procedure were very pronounced. The blood vessels of the conjunctivae, the mucous membranes of the nose and mouth, were all first lightened,then,if the stimulation were continued, reddened and congested with blood of rather a purple color, as if it were flowing more slowly than its custom. The flow of saliva was increased. The pupils attained very great size, if the stimulation were continued for a few minutes. The upper lids were drawn upward and the eyeball protrudes. The tears were increased, and often overflowed. All of these effects are due to the stimulation of the superior cervical ganglion.

Since the effects are so pronounced when this stimulation is given for only a few minutes, the effects upon the cranial vascular system of abnormally contracted muscles pressing upon the sympathetic ganglia can certainly not be disregarded with impunity. It is extremely difficult to secure adequate inhibition of the anterior cervical structures, because of the propinquity of the pulsating carotid arteries.

Stimulation of the tissues over the cervical vertebrae in persons, as in animals, caused contractions of the cervical muscles, but no effects upon the cranial structures were discerned, except such as could be referred to the effects of the pressure of these contracted muscles upon the sympathetic trunk and ganglia.

Mental Effects.

In no case were we able to affect mental conditions by manipulations planned to stimulate or inhibit the action of vaso-motors to the brain. Changes produced in the size of the vessels of the cranial structures sometimes caused headache and discomfort, but not ever any consciousness of sleepiness or of increased mental vigor, such as accompanied the various manipulations affecting blood pressure which were made upon the abdominal viscera. These experiments do not deny the existence of vaso-motor nerves to the brain, but they do not demonstrate them.

So far as our present knowledge goes, we must consider that the circulation through the brain is most easily affected through changes in the general blood pressure and that this is most easily controlled by affecting the size of the blood vessels, in the splanchnic area, and in some cases, by affecting the efficiency of the heart beat.

Centers for the Cranial Structures.

The superficial or osteopathic centers for the control of the cranial structures may thus be located as follows:

For the eyes, the level of the first and second thoracic vertebrae. Lesions of the vertebrae or muscles higher and lower than these may affect the eye tissues also. The eyes may be affected by direct manipulation of the superior cervical ganglion, and lesions affecting this ganglion may affect any of those structures of the orbit which receive innervation by way of the sympathetic system.

For the nasal mucous membrane, the second and third thoracic vertebrae. Lesions higher and lower than these, and lesions affecting the superior cervical ganglion may also affect the circulation of the nasal membranes. The relation of upper thoracic and cervical lesions with adenoids is very significant.

For the pharyngeal structures, the third and fourth thoracic vertebrae. Here, as in the other cases, lesions of the vertebrae above and below those mentioned may affect these structures. Lesions affecting the middle and superior cervical ganglia directly may exert an evil influence upon the circulation and metabolism of these structures.

The centers for the trachea and larynx are not to be at the level of the third thoracic. Lesions affecting the nerves of this and neighboring spinal segments, as well as lesions affecting the middle and superior cervical ganglia, may affect the thyroids through their nerves. Other lesions affecting the thyroids by direct impingment upon their vascular and lymphatic drainage were not subjected to experiment.

The centers for the traches and larynx are not to be distinguished from those for the upper lobes of the lungs.

COLLATERAL READINGS.

Olfactory Motor Paths, in Morat's Physiology of the Nervous System, p. 643, Edition of 1906.

Vaso-Motor Nerves and Reflexes, in any text book of Physiology.

CHAPTER XXIV.

THE EXPERIMENTAL DEMONSTRATION OF THE OSTEOPATHIC CENTERS: THE ARMS.

The variations in the blood supply to the hands and arms have been investigated by means of a series of experiments upon human subjects. For this work, the plethysmograph was used.

The Plethysmograph.

A plethysmograph is a glass cylinder provided with a rubber cuff and with stop cocks and rubber tubes. The subject's hand is enclosed in the cylinder, the rubber cuff surrounds the arm, and one rubber tube leads to the tambour, a pan covered with sheet rubber, upon which rests a needle. The needle plays upon a revolving drum covered with smoked paper. The plethysmograph and tambour are filled with water, oil, or air, according to the conditions of the experiment. If the size of the hand, as it is enclosed in the cylinder, should increase, the fluid in the cylinder would be presed into the rubber tube and into the tambour pan. The rubber cover of the tambour pan would be forced up, and this would lift the needle resting upon it. The needle thus writes the record upon the smoked paper.

Contracted muscles occupy a very little less space than relaxed muscles, hence, when the fingers are strongly flexed, while the hand is encased in the plethysmograph, the needle is permitted to fall. But after the muscles are relaxed, the blood flows into the hand in increased amount, and the needle is sent up again, higher than before the muscular contraction.

Very slight changes in the amount of blood in the hand and forearm are recorded by this apparatus.

The effects of the artificial lesion and of the various stimulating and inhibiting manipulations upon the blood supply to the arms are as follows:

Stimulation of the tissues near the roots of the nerves which make up the brachial plexus produced slight effect, and that only after a long latent period, and with an amount of stimulation which occasioned a really painful sensation. It appears from these experiments, that such manipulations were only indirectly effective, probably through the sensory fibers of the brachial plexus and the chief vaso-motor center in the medulla.

Stimulating movements applied to the brachial plexus under the clavicle caused a decrease in the blood supply to the arm, evidently by causing the constriction of the arterioles. This manipulation was followed by an increase in the blood supply, beyond that originally present. It appears, then, that the brachial plexus carries the vaso-motor nerves from this point. Anatomically, it is known that the brachial nerves receive gray fibers from the ganglion stellatum.

Stimulating manipulations to the tissues near the first second and third thoracic spines caused no perceptible effect upon the blood supply to the arms and hands.

Stimulating manipulations to the tissues near the fourth and fifth thoracic spines caused a decreased amount of blood in the hands. This reaction must be due to vaso-motor nerves to the hand. The stimulation of this center is known to cause a constriction of the pulmonary arterioles, and this must raise the blood pressue. The effect produced upon the arterioles of the arm by this manipulation is evidently sufficiently pronounced to overcome the effects of the increased blood pressue.

The artificial lesion in the same area causes an increased amount of blood in the hand. This, again, is directly oposite to the effect which is to be expected if the pulmonary vaso-motors were alone active under these circumstances

Stimulating manipulations given to the centers below the sixth thoracic spine caused an increased flow of blood to the hand. The vaso-motors to the hand were evidently not themselves affected by this manipulation. The stimulation of these centers—i. e., below the sixth thoracic spine— causes a constriction of the vessels in the liver and intestines, the systemic blood pressure is thus raised, and the blood flow to unaffected parts of the body is increased.

In the same manner, the artificial lesion below the sixth thoracic spine caused a decreased blood flow to the hands. That is, the artificial lesion below the sixth causes a dilatation of the vessels in the liver and intestines, and the blood is mechanically drained away from the other parts of the body, including, of course, the hands and arms.

The osteopathic or superficial center for the arterioles of the arms is therefore found near the fourth and fifth thoracic spines.

In a number of instances of injury to the hands and fingers, in persons otherwise healthy, there were reflex muscular contractions near the fourth and fifth thoracic spines. Muscular contractions near the origin of the fibers of the brachial plexus were less constant.

In some case reports of Raynaud's disease, Dr. J. L. Adams describes lesions affecting the fourth thoracic vertebra, and he reports favorable results from the correction of these lesions.

No experiments were performed for investigating the centers controlling the vaso-motors to the legs.

COLLATERAL READINGS.

Raynaud's Disease, any text book of medical practice.
Raynaud's Disease, McConnell and Teall's Practice of Osteopathy.
Raynaud's Disease, A. O. A. Case Reports.

CHAPTER XXV.

THE EXPERIMENTAL DEMONSTRATION OF THE OSTEOPATHIC CENTERS: THE LUNGS.

In the series of experiments described in this chapter some of the work of Dr. Pearl A. Bliss in her demonstration of the vaso-motor nerves of the lungs will be used.

Pulmonary Viscero-Somatic Reflexes.

The thorax was opened under ether narcosis. A Du Bois-Raymond coil was used for the electrical stimulation. The current was not measured but was barely perceptible to the touch of the wet finger. The electrodes were first applied to the visceral pleura of the upper lobe of the left lung. The first intercostals of the left side were strongly contracted. The muscles near the second thoracic spine were also contracted on both sides. After the stimulation had been maintained for several minutes, the intercostals of the right side, the muscles of the neck, especially the scaleni and the sterno-cleido-mastoid, and nearly all of the inter-scapular muscles became somewhat contracted.

The electrodes were then placed upon different areas of the visceral pleura. The intercostals normally covering the area stimulated were first contracted. Stronger stimulation initiated the contraction of the corresponding intercostals on the opposite side also.

The lobes of the lung were then displaced, but not cut. The stimulation of the visceral pleura of any part of the lung was followed by the contraction of the intercostal muscles normally covering that part, and by the contraction of the spinal muscles of the same and adjoining segments. This proved that the reactions observed were not due to any local effect of the electrical current, but were true reflexes, initiated by the electrical stimulation of the sensory nerves of the pleura.

Contraction of the diaphragm, the quadratus lumborum, and occasionally the abdominal muscles followed the stimulation of the lower lobes of the lungs. In the dog, the inferior lobe on the right side lies next the diaphragm but does not touch the thoracic wall. The stimulation of this lobe initiated the reflex contraction of the diaphragm but not of the intercostals unless the stimulation was maintained for some time. The division of the phrenic prevented this last reaction.

The removal of the visceral pleura in the areas stimulated rendered the reactions much more diffuse,—that is, the reflex muscular contractions were not so strong, and involved a much larger area. They were otherwise unchanged. The phenomenon probably indicates that the innervation of the pleura is more nearly exactly segmental than is the innervation of the pulmonary epithelium. This accords with circumstances of the development of these tissues. The pulmonary epithelium arises as an out growth from the pharyngeal epithelium, and as it grows downward it carries with it its original nerves, the vagi, and later receives its vaso-motors with its blood vessels. The pleura, on the other hand, is developed in place from the mesoblast of that region, and retains both its position and its innervation throughout life.

Section of the Vagus.

The section of one or both vagi above the superior cervical ganglion did not perceptibly affect the results. Section of both vagi below the superior cervical ganglia lessened the reactions in a very variable manner in different animals. After section of both vagi below the stellate ganglia, or after the extirpation of the stellate ganglia without injury to the vagi, or after the destruction of the upper part of the spinal cord, no contraction of striated muscles could be discerned upon the administration of such stimulation as we were employing.

The spinal muscles were variously contracted during the application of the stimulation to the lungs. The most marked contractions were noted in the area of distribution of the second, third, fourth, and fifth spinal nerves. There is a slight appearance of segmentation in the areas of these reflex contractions. Hence, the location of the reflex muscular contractions affords some information concerning the location of areas of irritation in the lungs and pleura, especially in the early stages of disease, before the reflexes have become spread into the neighboring segments.

The place of these reflexes in pathology may be referred to briefly in this connection. The irritation of the pleura by any of the causes of its disease initiates the contraction of the intercostals covering the affected area, and rest is thereby secured for the injured tissues. If the irritation is very severe, the whole thorax becomes practically immovable. Conversely, the contraction of these spinal muscles exerts an influence upon the circulation and nutrition of the injured lung which is at first curative, but becomes decidedly detrimental to recovery if the irritation be long continued.

Pulmonary Somato-Visceral Reflexes.

The relations determined by these experiments were held indicative of certain possibilities in testing the nature of the somato-visceral reflexes. In the first experiments the electrodes were placed upon the skin in the area of distribution of the chosen nerve. The visceral effects thus secured were inconspicuous and inconstant. The fact that any visceral effects were secured, even though they were neither constant nor pronounced, shows that the skin may, in occasional cases, be a source of visceral mal-function through reflex effects upon the visceral nerves. Since the skin and other superficial tissues are normally subjected to great variations in stimulation, the changes needful to produce any considerable visceral effect must be very great or else very unusual in their quality. The visceral effects following the injury of extensive skin areas are probably produced in this way.

Mechanical stimulation of the sensory nerves in the deeper muscles, articular surfaces, and adjacent tissues initiated decided visceral effects. Those movements which affected the joint surfaces most urgently were most effectual in producing vascular changes.

The thorax remaining intact, and the abdomen being opened, the color of the lungs was noted through the central tendon of the diaphragm. In dogs, this tendon is usually very large and thin, and the changes in the color of the lungs can be seen quite easily in a good light. In cats, the central tendon is smaller and thicker. Hence the cat is not a proper subject for this experiment. In dogs, mechanical stimulation of the deeper tissues near the fourth and fifth thoracic spines was followed, after a latent period of from one to three minutes, by a lightening in the color of the lungs. After a few minutes rest they began to redden again, becoming somewhat deeper in color than they were before the stimulation. The stimulation was again given in the same area, when the lungs again became lighter, only to redden again under rest. There seemed to be no limit to the number of times the reaction could be repeated, provided the anesthesia were not too profound, and provided sufficient time were given for the return to the normal condition between the periods of stimulation. It is evident that the changes observed were due to changes in the caliber of the pulmonary blood vessels.

Experiments performed in the same manner, except that the stimulation was applied to other spinal areas, or to the trunk of the vagus, were not successful. No stimulation of the vagus seemed to exercise any effect upon the circulation through the lungs except those evidently attributable to cardiac effects. Certain effects were produced upon the bronchial musculature by stimulation of the vagus which required further investigation.

Again, with the thorax intact and the abdomen opened, the fourth and fifth thoracic spines were held firmly in such a manner as to force them slightly out of their normal alignment, without actually dislocating the vetrebrae. Thus the "artificial lesion" was produced. After a latent period somewhat longer than before, the lungs became redder than normal.

This appearance persisted as long as the lesion was maintained. If the lesion were removed quickly, the normal color slowly returned. The longer the lesion was maintained, the longer the time required for recovery. Recovery from the second experiment upon the same animal was very slow, and the animal often died before recovery from the third experiment, even though the lesion had been maintained each time only long enough for the effects to become manifest.

In the next series the thorax was opened. The same effects followed the same manipulations. Stimulation of the tissues near the second and third thoracic spines seemed to produce greater effects upon the circulation in the upper lobes of the lungs than did the stimulation of the tissues near the fourth and fifth spines. No actual measurements were possible under the conditions of our experiments, but differences in the color changes seem to warrant the statement just made. It is apparent that the somato-visceral reflexes are much more diffused and irregular than the corresponding viscerosomatic reflexes.

Stimulation of the tissues near the second and third thoracic spines affected many other tissues also, and for this reason it seems probable that the centers most effective for modifying the circulation through the lungs are found near the origin of the fourth and fifth thoracic nerves.

In order to eliminate cardiac effects, the cardiac nerves were all divided. The reactions described above did not vary after the section, except that the animal did not live so well under anesthesia, and the experiments could not be so often repeated.

Experiments Upon Human Subjects.

The following expericents upon human beings can be repeated quite easily. The subject was permitted to rest quietly until the blood pressure remained constant. The blood pressure was then estimated by means of the sphygmomanometer. Stimulation of the tissues near the origin of the fourth and fifth thoracic nerves was followed by a rise in blood pressure, such as would be caused by the contraction of the blood vessels in any marked area of the circulatory system. In the light of the experiments upon animals just described, it appears that this increase in blood pressure is due to the decrease in the size of the pulmonary vessels.

Deep, steady pressure at the sides of the spines, or the maintenance of an artificial lesion in the same area, is followed by a decrease of blood pressure, such as would follow a dilatation of the vessels in any large area of the vascular system. This effect is, for the same reasons, held to be due to the lessened action of the pulmonary vaso-constrictors.

Figure 4 and figure 5 show the effects of these manipulations upon the respiratory curves. The subjects were permited to remain quiet upon a treating table until no further change in pulse or respiration could be detected. The normal curve was then taken, then the manipulations administered, then a second tracing was taken, with the same apparatus similarly placed. These curves were taken many times with many different persons as subjects, and the results were always alike, in the main, though they differed considerably in detail. In many instances, the curves varied in answer to the manipulations very much more than do those which were used in the cuts. These were chosen as representative of the average changes produced by the manipulations described.

The respiratory curves were taken with Marey's tambour. This consists of two pans connected by rubber tubes. Both pans were covered with thin sheet rubber. One pan was bound over the apex beat of the heart, the other supported a needle which played upon a smoked paper around the revolving drum of a kymograph. The pressure of the respiratory movements and of the heart beat was transmitted through the fluid in the first pan, then through the tube to the second pan, where the needle was affected, and the needle wrote the record upon the smoked paper. The paper was then varnished and the records preserved. The large waves are those produced by the respiratory movements, and the smaller waves superimposed upon the respiratory curves are made by the heart beat.

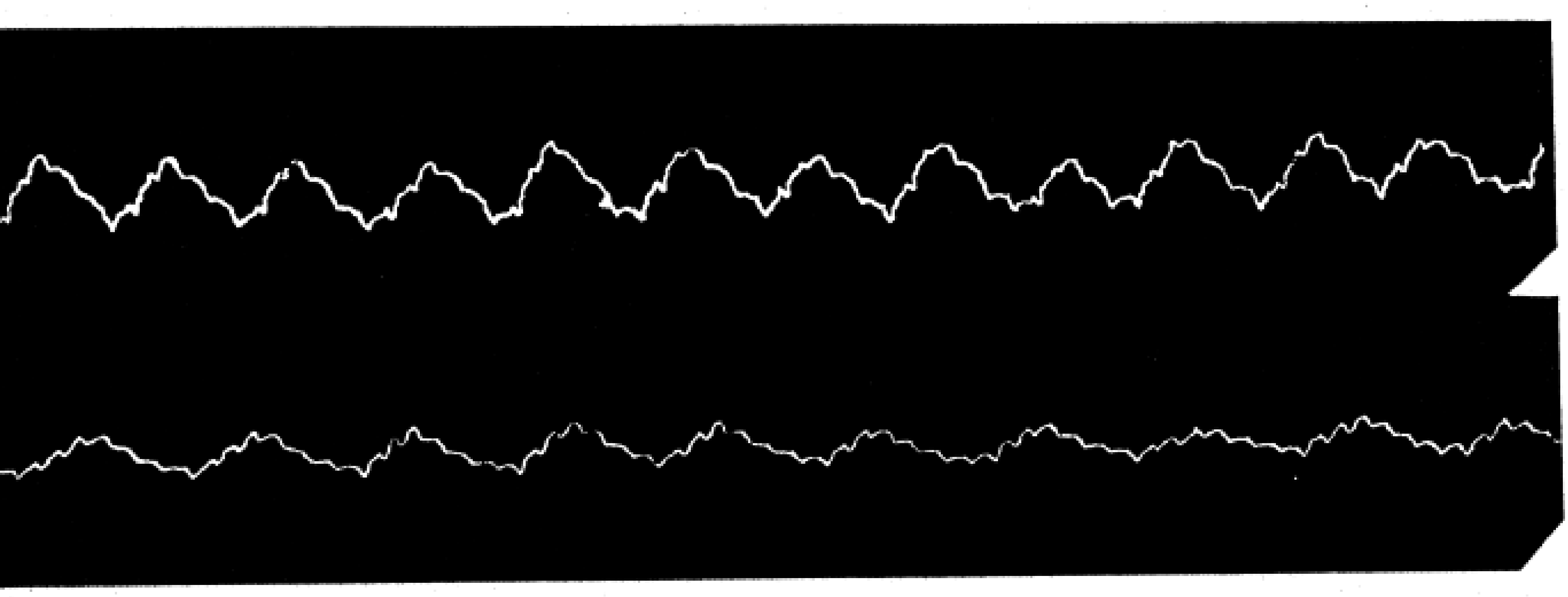

FIGURE 4.

Upper tracing, normal, resting respiratory curve. Blood pressure, 110 m. m. of mercury. The smaller waves were made by the heart's beat.

Lower tracing, respiratory curve after the maintenance of an artificial lesion of the fourth thoracic vertebra for three minutes. Blood pressure, 99 m.m. of mercury.

The lesion causes slight dilatation of the pulmonary vessels, increased oxygenation of the blood, and decreased activity of the respiratory center. The decreased blood pressure is due to the dilatation of the pulmonary vessels.

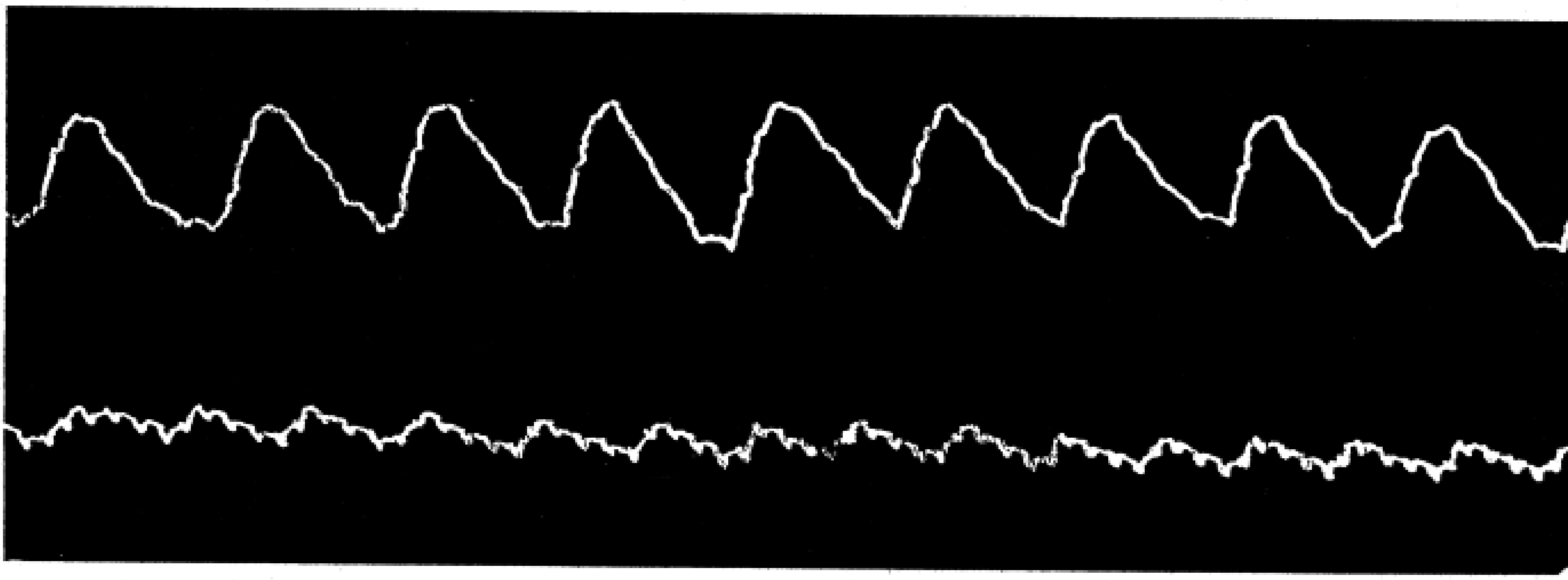

FIGURE 5.

Lower tracing, resting, normal respiratory curve. Blood pressure, 116 m.m. of mercury. The smaller waves were made by the heart's beat.

Upper tracing, respiratory curve after stimulation of the tissues near the fourth thoracic spine. Blood pressure, 121 m.m. of mercury.

The stimulation caused constriction of the pulmonary vessels, decreased oxygenation of the blood, and increased activity of the respiratory center.

It was noted in the observations upon anesthetised animals that the reflex effects upon the heart disappeared much more quickly under the anesthesia than did the vaso-motor reflexes. That is, under anesthesia the cardiac nerve centers first lose their power of replying to sensory impulses, while the irritability of the vaso-constrictor centers persists under more pronounced anesthesia. This is true also of the same nerve centers during the process of dying under certain other poisons.

The experiments upon human beings were, of course, carried on without anesthesia. The cardiac centers were therefore normally active. When the human subject slept, however, the cardiac reflexes were less conspicuous than the vaso-motor reflexes, just as in the case of the anesthetized animals. It seems that sleep and anesthesia alike differ from the waking condition in this particular, as well as in others which are more familiar.

In these experiments upon human beings, the effects described in this chapter were constant only as described if the subject were in fairly normal condition. If the inter-scapular muscles were contracted or if the manipulation was painful the effects varied in some instances. Any manipulation, whether stimulating movements or steady pressure, seemed to effect the relaxation of the muscles, and a return to the normal condition.

These effects are explained as follows:

During the period of the abnormal contraction of the inter-scapular muscles, however produced, the reflex effect upon the pulmonary vessels was such as was produced by the steady pressure of the experimenting fingers. The vessels were dilated in the same manner as was seen in the vessels of the animals subjected to the same experiment. Any manipulation of these muscles resulted in their relaxation, and in the return of the whole circle of sensory, vaso-motor and association neurons and the vascular musculature to the normal condition. It seems that contracted muscles or bony lesions in the area of the lung center or its immediate neighborhood exert an inhibiting influence upon the vaso-motors of the lungs, leading to their dilatation, and to low systemic arterial pressure. The relaxation of these muscles or the removal of the lesions, however secured, removes the source of the abnormal sensory impulses. Then the circulation becomes normal as soon as the vascular walls and the neurons affecting them recover from the effects of the abnormal influences.

COLLATERAL READINGS.

The Pulmonary Vaso-Motors, Dr. Pearl A. Bliss, A. O. A. Journal, August, 1907.

CHAPTER XXVI.

THE EXPERIMENTAL DEMONSTRATION OF THE OSTEOPATHIC CENTERS: THE HEART.

Cardiac Viscero-Somatic Reflexes.

The centers for the heart were determined in much the same manner as were the lung centers.

The electrodes were placed first upon the different parts of the parietal pericardium. This stimulation was followed by contractions of the muscles near the fourth thoracic spine. The areas of the third and fifth nerves were also affected in some animals, but the muscles innervated from the fourth thoracic nerve were always affected, as were also the intercostals of the same area. The intercostals of the third and fifth nerves were more frequently affected than were the spinal muscles of the same area.

The stimulation of the visceral pericardium gave the same reactions, as did also the stimulation of the heart muscle. The direct stimulation of the heart muscle, however, initiated one reaction which was not found in connection with the stimulation of the pericardium. This was the contraction of the cervical muscles. The trapezius was almost invariably affected, and the scaleni very often. Other cervical muscles were reflexly contracted in reply to stimulation of the heart muscle in varying degrees in different animals. No difference in the position of the muscular contraction could be determined in relation with the stimulation of the different valves. Indeed, it was very difficult to secure any reactions in answer to the stimulation of the valves or of the endocardium, unless the strength of the current was so greatly increased as to affect the heart muscle also. The sensory nerves of the heart are evidently distributed to the cardiac musculature more freely than to the endocardium.

Cardiac Somato-Visceral Reflexes.

The stimulation of the tissues near the fourth thoracic spine initiated changes in the heart beat which are of two kinds. In some individuals the strength of the beat is increased, in others the rate, while in yet others both rate and force are increased. Whether this difference is due to some imperceptible difference in the manner of giving the stimulation, or whether it is due to some physiological difference in the metabolism of the neuron systems concerned, or whether it is due to structural peculiarities or to some other factor, we do not know. This is one of the points which awaits further investigation. The facts are as stated.

Stimulation of the tissues near the fourth thoracic spine of an animal whose thorax has been opened under anesthesia affects the pulmonary blood vessels rather than the heart. The heart is quickened if it is affected at all. Without anesthesia or mutilation, the heart is always quickened, and usually the beat seems somewhat less forceful to the touch.

Direct Stimulation of the Sympathetic.

Direct stimulation of the sympathetic ganglia in the upper thoracic region caused great increase in the rate of the heart beat. Direct stimulation of the vagus above the superior cervical ganglion decreased the pulse rate. Stimulating manipulations of the vagus, in the absence of anesthesia or mutilation, lessened the rate if the stimulation were given high in the neck, but increased the rate if the stimulation were given just above the clavicle,—or rather, in animals, the place where the clavicle would be if there were one. The reason for this seeming anomaly is that the sympathetic fibers which reach the heart are carried with the vagus from their exit from the superior, middle or inferior cervical ganglia. The accelerators are more immediately effectual, hence the stimulation of the nerve trunk at a point where it carries both kinds of fibers causes the accelerator effect to be most evident.

Stimulation of the vagus below the heart, as, for example, just above the diaphragm, initiates inhibitor influences to the heart. These are reflex, and are of the same nature as those impulses of gastric origin which interfere with the heart's action under certain abnormal conditions. Stimulation of the vagus nerve in the neck is rather an easy matter; its inhibition is rendered rather difficult by the presence of the pulsating carotid artery. Pressure upon the nerve increases the effect of the pulsations of the artery upon it, and the effect of this is the stimulation of the vagus, rather than its inhibition.

The most satisfactory experiments upon the action of the heart centers were performed upon persons.

Experiments Upon Human Subjects.

Stimulation of the tissues near the fourth thoracic spine caused an increase of as much as fifteen beats per minute in the pulse rate. In those persons in whom the rate was greatly increased, the force of each beat was somewhat lessened. The utmost efforts at stimulation were unable to increase the pulse rate at all in some individuals.

In all, when efficient stimulation was given, the blood pressure was raised. This reaction was no doubt partly due to the simultaneous reflex stimulation of the pulmonary vasomotors, and in part to the cardiac effects. The rise of blood pressure thus produced may amount to twenty millimeters of mercury in some individuals. In others, the effects are much less pronounced. Efficient stimulation always produces some change, however, in a normal person.

The effect of this stimulation upon the sphygmogram is usually very pronounced. In persons whose muscles are very heavy, and who have been of robust health for a long time, it requires a considerable amount of strength to effect the deeper muscles in sufficient degree to effect a perceptible change in the sphygmogram.

FIGURE 6.

Upper sphygmogram, normal, resting pulse. Rate, 71. Blood pressure, 125 m. m. of mercury.

Lower sphygmogram, after two minutes of the "artificial lesion" the fourth thoracic spine. Rate 82. Blood pressure, 133 m. m. of mercury.

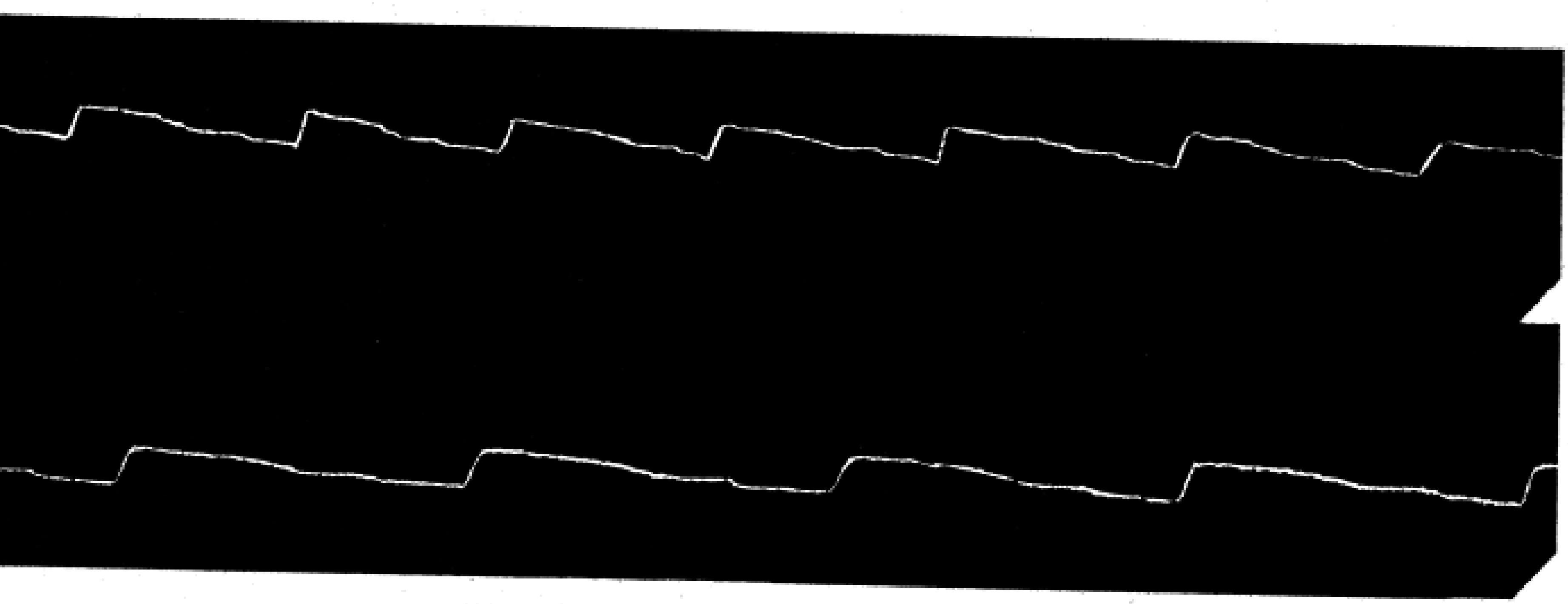

FIGURE 7.

Upper sphygmogram, normal, resting pulse. Rate, 72. Blood pressure, 119 m. m. of mercury.

Lower sphymogram, after two minutes of the "artificial lesion" at the fourth thoracic vertebra. Rate 63. Blood pressure, 113 m. m. of mercury.

Stimulation of Heart Center.

It is usually easy to secure rather striking variations in the sphygmograms in reply to the stimulation of the heart center by somato-sensory impulses. These experiments were performed in the following manner:

The subject was permitted to rest until the pulse displayed no further change.

The normal, resting sphygmogram was then taken upon about half the strip. The clockwork was then stopped while the stimulating movements were given to the tissues near the fourth thoracic spine for two to four minutes. The sphygmograph was then started, and the character of the pulse tracing noted. If no change was perceptible, the stimulation was repeated. The second attempt was always successful, if the stimulation was properly given. The sphygmogram showed increased rate, or force, or both. If the rate were greatly increased, the force of each wave was sometimes less than before the stimulation was given. If the force was greatly increased, the rate sometimes remained nearly or quite unchanged. It has never occurred that the rate was decreased unless there were some abnormality present. Under normal conditions, the efficiency of the heart's beat is always increased by this stimulation.

Inhibition of Heart Center.

The artificial lesion in the neighborhood of the fourth thoracic spine lessens the efficiency of the heart beat. This is due either to decreased rate, or decreased force, or both, at first, but after a few minutes persistent inhibition, or the maintenance of the lesion for a few minutes, the beat becomes quick and weak in all cases.

The sphygmograms taken after prolonged treatment of this kind show the decreased power of the up stroke; it is not so high as before, and its slant is greater.

The systemic arterial pressure is decreased at the same time. This decrease in blood pressure is no doubt partly due to the dilatation of the pulmonary vessels, but in part it depends upon the lessened efficiency of the heart's action.

In some of the subjects of these experiments, the interscapular muscles were contracted in an abnormal manner, and the manipulations were painful. Any manipulations which were given secured the relaxation of the stiffened muscles and a temporary return to the normal condition of the pulse. The effect was usually only temporary, except in a few cases in which the muscles had been stiffened by some temporary condition. In these cases, the manipulations afforded the temporary relief which was all that the conditions required.

The pressure upon the sensory nerves which is maintained by muscles which are kept contracted is exactly the same in kind as the pressure which is exerted by the fingers in the experiments in inhibition. The effects are the same, except that the contracted muscles persist in their pressure for days and nights, until the neurons concerned are exhausted. The relief of the abnormal contractions, however secured, stops the abnormal sensory impulses and permits the normal relations to be effectual as soon as the neurons are able to regain their normal metabolic conditions.

The effects of abnormal conditions effecting the vagus are very irregular. The experimental pressure upon the trunk of the vagus in the animal produces at first a slowing of the heart. This is followed by a period of irregular rhythm, and this is maintained as long as the pressure is continued. The irregularity of the rhythm noted in these cases is probably due to the complexity of the factors which regulate the heart's action.

It appears from these experiments that the action of the heart may be affected by somato-sensory impulses from the area of distribution of the fourth thoracic nerves, and that those movements are most effectual which affect the relations of the joint surfaces.

Abnormal conditions affecting the somato-sensory impulses carried over the third, fourth and fifth thoracic nerves may exert a direct influence upon the heart's action.

Any condition which affects the sensory fibers of the vagus may affect the action of the heart.

No aid in the diagnosis of valvular lesions is to be expected from the existence or non-existence of reflex muscular contractions in the inter-scapular region.

CHAPTER XXVII.

THE EXPERIMENTAL DEMONSTRATION OF THE OSTEOPATHIC CENTERS: THE ABDOMINAL VISCERA.

Viscero-Somatic Reflexes.

The first series of experiments upon the abdominal viscera were performed upon animals. The abdominal wall was opened under anesthesia. The viscera were exposed to examination with as little manipulation as possible. The condition of peristalsis and the size of the blood vessels was carefully noted. The fingers of the observers were placed upon different areas of the back and neck, in part of the experiments, and in others the muscles also were exposed to view. For the first series, electricity was used except where other forms of stimulation are mentioned.

The stimulation of the peritoneal coat, or the muscles, or the inner wall of the cardiac end of the stomach was followed by the contraction of the muscles near the sixth to the eighth thoracic spines. The inner walls of the stomach were stimulated by pricking and by the use of a hot glass rod. The reflex muscular contractions followed as in the case of the electrical stimulation. The stimulation of the peritoneum and the gastric muscles by pricking, etc., did not initiate the contractions so constantly. The area of reflex muscular contractions varied somewhat in different animals, but remained constant for each animal, at least during its life under anesthesia. Electrical stimulation of the pyloric end of the stomach gave rise to contraction of the spinal muscles from the seventh to the tenth, but usually near the ninth thoracic spine. This corresponds to the eighth in the human being.

In all these experiments, the cervical muscles were somewhat contracted. We did not determine what individual muscles were involved in the reaction.

The stimulation of the duodenum, pancreas and gall-bladder caused the contraction of the muscles near the tenth and eleventh thoracic spines. (It must be noted that cats and dogs rejoice in the possession of one or two extra thoracic vertebrae.)

The stimulation of the rectum was followed by contractions of the muscles near the lumbo-sacral articulation. The stimulation of the portions of the intestine between the duodenum and rectum caused muscular contractions which were fairly equally divided between the tenth thoracic spine and the lumbo-sacral articulation. The stimulation of the caecum and appendix caused the reflex muscular contractions to appear near the fourteenth thoracic and the first lumbar spines. The interior of the appendix was stimulated by pricking, and the reflex contractions appeared as before.

The electrical stimulation of the kidneys and the supra-renals caused the contraction of the muscles near the fourteenth thoracic spine, sometimes the contractions appeared near the twelfth and thirteenth. These correspond to the eleventh and twelfth in man.

The electrical stimulation of the small intestines was very efficient in producing the reflex contractions. The neighborhood of the caecum was especially sensitive to any stimulation. Reflex movements were very easily initiated from this region by slight stimulation. The colon, on the other hand, was not apt to give rise to the reflexes unless the stimulation was very strong. Prickings, etc., of the inner wall had almost no effect in producing the reflex muscular contractions. The peritoneum over the intestines seemed to be of about the same sensitiveness throughout, so far as we were able to determine. So far as the initiation of reflex muscular contractions can be considered a criterion, the caecal region is the most sensitive part of the intestines, the duodenum is next in order, the other parts of the small intestine about alike, and the colon is least sensitive of all. The rectum is even more sensitive than the caecal region in its very lower portion, near the anus, but the upper part of the rectum is not more sensitive than the colon. Stimulation of the anal tissues caused very intense contractions of the sacral muscles, and usually of the leg muscles also.

The stimulation of the anal tissues, and sometimes those of the caecal region caused the contraction of the cervical muscles also. In some cases, the stimulation of the kidneys and supra-renals caused the contraction of the cervical muscles, but this reaction was not constant.

Somato-Visceral Reflexes.

The centers thus suggested were then used for further work in the determination of the somato-visceral reflexes.

Stimulating manipulations were given to the tissues near the sixth and seventh thoracic vertebrae. Gastric peristalsis and secretion were found to be increased after a latent period of about five minutes. Soon after, the peristaltic waves appeared in the walls of the intestines. At the same time, the viscera were found to be lighter in color. By the use of a reading glass, the constriction of the small arterioles was very apparent. The blood pressure seemed to be raised, judging by the character of the heart beat, though it was not measured in any of the animals. A slight rise in temperature was perceptible to the touch, though the intestines were exposed to the air and no effort was made to conserve the heat. It was not possible, under the conditions of our experiments, to affect the secretion and movement of one part of the stomach rather than another, nor to affect the stomach to the exclusion of the duodenum. The stomach center may then be located in the sixth to the eighth thoracic segments of the cord. The artificial lesion in this area was followed by a relaxation of the walls of the stomach, a dilatation of its vessels, and its distension with gas. The duodenum was always affected to some extent by anything which affected the stomach.

Stimulating manipulations of the tissues near the eighth to the tenth thoracic vertebrae caused contractions of the blood vessels of the pancreas. The effects upon the pancreatic secretion were not studied.

Stimulating manipulations of the tissues in the neighborhood of the tenth to the fourteenth vertebrae was followed by increased peristalsis of the duodenum and small intestines, and by characteristic vascular changes. The walls of the viscera became lighter in color, and the arterioles were contracted, as seen with the realing glass. The blood pressure was greatly increased, as was evident from the character of the pulse changes.

Artificial lesions in the same area produced conspicuous effects. The vessels became dilated, and the color of the blood within them became darker and more of a purple hue, as if it were more nearly venous than before. Blood pressure was decreased. The visceral walls were relaxed, and the intestines became distended with gas.

Gas in the Intestines.

The gas found in these cases was set free by the blood. The amount of gas which can be carried in a solution varies with the pressure and temperature of the solution. The temperature of the body remains fairly constant, and can be disregarded. Blood under high pressure can carry a certain amount of carbon dioxid in solution. If the pressure of the blood in the vessels is decreased, the blood is not able to dissolve so much of the gas, and it is therefore set free wherever the pressure is lowest. Under the conditions of our experiment the gas could not have been due to fermentation. In the case of persons who suffer from flatulence it is probable that part of the gas, at any rate, is due to fermentation. The tests made to determine the origin of the gas in the experimental cases were as follows:

The intestines were exposed to view as before, and their condition noted. Large, soft cords were then tied around the intestines at intervals. The ligatures were carefully placed to avoid the large blood vessels and nerves. The mesentery was merely punctured. The cords were tied tight enough to prevent the passage of gas from one division to another. The intestines were cut in some places. No gas escaped, hence the gas was not present in the intestines at the beginning of the experiment.

The artificial lesion was produced, or, in some cases, inhibition was given, in the region of the eighth to the twelfth thoracic vertebrae. All of the intestinal vessels were dilated, the blood pressure became lowered, and the uninjured areas of the intestines between the ligatures became distended with gas. Puncture of some of these areas permitted the escape of an almost odorless gas, which we supposed to be chiefly carbon dioxid. Gas was often eliminated by way of the anus at these times.

Other sections of the intestines whose walls between the ligatures were still intact remained distended with gas for some time. After the artificial lesion was removed, the blood vessels and the intestinal walls returned to their normal condition very slowly, and the gas disappeared. Puncture of these sections of the intestines was not then followed by the escape of gas.

The artificial lesion, then, caused congestion of the intestinal tract, lowered blood pressure, and the accumulation of gas in the intestines. The possibility of an accumulation of gas in the peritoneal cavity is being investigated. The absorption of the gas after stimulation of the splanchnic area must have been by way of the blood or lymph to the lungs, for there was no other pathway of escape for it. (Note A.)

The return to the normal appearance after the pressure was removed was very slow, indeed, if the artificial lesion had been maintained for a long enough time for the effects to become pronounced. Subsequent stimulation of the tissues in the same area hastened the return to the normal appearance of the vessels, but was sometimes followed by reversed peristalsis.

Direct stimulation of the splanchnic nerves by electricity or by pricking the nerve trunk caused lessened peristalsis, under the conditions of our experiments, and dilatation of the splanchnic vessels. No explanation is offered of this apparent paradox, but the facts are as stated. The phenomena were so often observed upon so many animals that it is not possible to suppose that some individual peculiarity is responsible for the condition.

The walls of the spleen became roughened by direct stimulation of its nerves, and also by the stimulation of the tissues near the eleventh thoracic vertebra. This reaction was possible only during the later stages of digestion.

The Supra-Renals.

Stimulating manipulations of the tissues near the thirteenth and fourteenth thoracic spines was followed by rather striking changes in the activity of the supra-renal capsules. Their blood vessels became dilated very conspicuously. At the same time the blood vessels of the intestines, stomach, pancreas, spleen, heart and lungs, the conjunctivae, and the mucous membranes of the mouth and nasal passages became greatly constricted. The pulse showed very high blood pressure. The blood vessels of the limbs and of the brain did not display such conspicuous effects. In some animals these vessels seemed to be affected by the activity of the supra-renals, and in others no effects whatever were visible. In the cases where the changes did appear, the dilatation may have been due to the increased blood pressure. The internal secretion of the supra-renals is supposed by some investigators to affect only the muscles of the blood vessels which are supplied with vaso-constrictors from the sympathetic ganglia. The limb muscles are poorly supplied with constrictors, and the constrictors of the brain have not yet been absolutely demonstrated. Our experiments do not yet throw any light upon these questions, and further investigations are in progress.

The artificial lesion in the same area was followed by increased caliber of the intestinal vessels and low blood presure, but we were not able to demonstrate any effect upon the vascular system which was beyond question due to the action upon the supra-renals of the artificial lesion in the center controlling these glands.

After Section of the Vagus.

The vagus nerves were sectioned in another series of experiments. The results already described were usually intensified in the animals subject to this mutilation. The direct stimulation of the splanchnic nerves by pinching, pricking or electricity initiated reversed peristalsis. This was so pronounced that in some cases bile was quietly ejected from the mouth. Bile was found in the stomach in every case in which direct stimulation of the splanchnic nerves followed section of both vagi. No active vomiting occurred after section of the vagus. In nearly every instance, direct stimulation of the intestinal or gastric walls initiated reversed peristalsis, Stimulating manipulations of the splanchnic area also caused reversed peristalsis in many instances, though not in every animal subjected to the experiment.

When both vagi were cut, the stimulation of the central end of either or both produced no visible effects upon the viscera. It seems that sensory impulses carried upward through the vagus nerves do not affect the activity of the splanchnics to any great extent, if at all. After the section of only one vagus, the stimulation of its central end caused very pronounced increase in the gastric movements. The impulses were evidently carried upward to the center in the medulla and downward by way of the intact nerve of the other side. The relation between the right and left vagus is, therefore, very close.

The nausea that accompanies a "stiff neck" may perhaps be referred to the effects of the abnormal pressure of the contracted muscles upon the vagus. The nausea and the vomiting of bile that annoys many of those "who go down to the sea in ships" may be referred to the irritation of the center for the vagus in the medulla by the excessive stimulation of the vestibular nerve, whose sensory nucleus is so closely associated with that of the vagus. The excessive stimulation of the vagus center exhausts its neurons, and the effect is similar to the experimental section of the nerve.

The vagus is sensory to various organs. If these are not normal, the liminal value of the vagus center is abnormally low, and is therefore easily affected by the abnormal stimulation from the center for the vestibular portion of the eighth nerve. If the organs from which the vagus carries sensory impulses are fairly normal, the center is able to maintain fairly normal metabolism for some time in the presence of the excessive vestibular impulses. Hence, the best preventive of sea-sickness is found in a normal condition of the area of sensory distribution of the vagus nerves. Variations in susceptibility are caused by variations in the liminal value of the nerve centers, by variations in the irritability of the vestibular nerve endings, and by variations in the structural relations of the nerve centers.

The Pathway of the Visceral Reflexes.

In another series of experiments, the sympathetic ganglia were removed.

None of the reactions involving the spinal muscles were to be secured under any circumstances.

The possibility of the passage of impulses through the sympathetic system alone was tested by a very exhaustive series of experiments upon many animals.

The spinal nerves were sectioned all along the splanchnic area. No reflex effects were to be secured, either visceral or somatic.

The most instructive tests were made upon peristaltic movements. Peristalsis is carried from one part of the intestinal walls to another from muscle to muscle if the nerves are cut or paralyzed by any of the poisons used for the purpose. If the intestine is sectioned the peristalic waves stop at the section, when the nerves are cut, but pass over the section if the nerves are intact. If the nerves from the semilunar ganglion are cut, peristalsis stops at the section of the intestine. If the sympathetic ganglia are extirpated, the peristaltic waves stop at the section.

Destruction of the spinal cord at the level of the origin of the white rami in relation with the intestines prevents the passage of the peristaltic wave over the intestinal section. It was thought that the shock of the destruction of the cord might account for the fact that the peristaltic wave was unable to cross the section.

The upper dorsal and the lumbar portions of the cord were destroyed and the splanchnic portion left intact. All the other nerves also were intact. The stimulation of the intestine above the section caused peristalsis which crossed the section as if the reflex arc were normal. Hence, the shock to the nervous system could not account for the phenomena observed. Other tests were made to eliminate the possibility of error in the interpretation of the results.

The series indicates that the chief, if not the only, path of reflex action involving the visceral muscles and glands passes through the spinal cord or the centers in the floor of the fourth ventricle and acqueduct of Sylvius. Reflex effects of one viscus upon another are carried by way of the cerebrospinal system. The sensory nerves carried with the sympathetic nerves originate in the sensory ganglia in the intervertebral foramina. They are thus enabled to affect the spinal muscles. The impulses which affect the viscera originate in the lateral horns of the spinal cord. The impulses from the cerebro-spinal sensory nerves are thus able to affect viscera. It is by means of this relation that bony lesions affect visceral action.

Note A.—In surgical operations the experiments performed upon animals are practically duplicated upon human beings. It has been found that during the operation under the surgical anesthesia the reflex muscular contractions occur in persons as in lower animals. The muscular contractions so produced, may, if they are permitted to remain present, be a cause of evil after affects. The inhibition exercised by contractions along the lower dorsal and lumbar regions may be a cause of post operative meteorism.

This view of post operative meteorism was taken by Dr. Maria S. Wing, of Los Angeles. An extract from a letter reporting her success is given here with her permission:

"On my arrival at the hospital I found the patient suffering greatly, with face drawn and anxious, sleepless, fast losing her strength and grip. The gas distended all the soft parts from the sternum to the pubic bone into one immense tumor, and the faithful nurses, under the guidance of an able, resourceful and experienced sister, had worked over her night and day without any improvement. Gas is, as they so often have seen, the great danger in abdominal surgery, and they have so often found their efforts inadequate. They had little hope for this case.

"I put my hand under her back and found the muscles very tense. Nor did they easily relax, but I kept up the manipulations until she told me with a moan that she was tired. By this time the muscles were fairly well relaxed, and I ordered a hot water bottle at her back. But the distension was unchanged and I began to feel discouraged. Then, in less than five minutes, she exclaimed in horror: 'Has the wound opened and let out the gas? It is gone!'

"And gone it was, without any escape by mouth or rectum. The abdomen was entirely collapsed. I had to explain to her how the blood was not carrying the gas to the lungs, that she would not have had any gas in case the blood had not been stagnant and that now all trouble was over. She sank into a deep, peaceful sleep that lasted until the next morning, and she has had neither pain nor other difficulties since then. Each time any sign of gas has appeared I have been sent for, and the relief is always immediate."

The patient referred to by Dr. Wing had suffered total hysterectomy. The incident described in the letter occurred upon the fifth day. The meteorism had prevented sleep from the time of the operation until the relief given by Dr. Wing. The experience has been duplicated since that time by Dr. Wing and by others.

Note B.—The following experiments were performed upon cats and white rats in order to determine whether gas might accumulate in the peritoneal cavity. Five animals were used.

The animals were anesthetized, the abdomen was opened under warm water, and the artificial lesion produced in the splanchnic area. Small bubbles of gas appeared upon the mesentery and omentum, became larger, and arose to the surface of the water. Gas appeared within the omental sac.

CHAPTER XXVIII.

THE EXPERIMENTAL DEMONSTRATION OF THE OSTEOPATHIC CENTERS: THE ABDOMINAL VISCERA—CONTINUED.

Experiments Upon Human Subjects.

The experiments upon human subjects verified the results secured in the experiments upon animals.

The first series of experiments upon human subjects were planned to determine the effect of stimulation, inhibition, and and artificial lesion upon systemic blood pressure.

It should be remembered that the experiments upon animals indicated the following facts:

The artificial lesion in the splanchnic area causes a dilatation of the intestinal vessels, a lowering of the systemic blood pressure, a relaxation of the gastric and intestinal walls, and the accumulation of gas in the stomach and intestines.

Mechanical inhibition in the same area produces the same results in less marked degree.

Mechanical stimulation in the splanchnic area causes increased peristalsis, decreased caliber of the blood vessels, increased systemic blood pressure, and the absorption of whatever gas may be present in the stomach and intestines.

Mechanical stimulation of the tissues near the thirteenth and fourteenth vertebrae causes a rise of blood pressure and a contraction of the arterioles in many parts of the body, and an increased heart action, by the effects of the increased action of the supra-renal capsules.

It is needless to say that these experiments could not be repeated upon human beings. But equivalent results were secured by use of harmless methods.

The first series of experiments upon human subjects were devoted to the determination of the effects of stimulation, inhibition, and the artificial lesion upon blood pressure.

The subject was permitted to rest quietly upon a treating table until the pulse displayed no further change. The blood pressure was then taken. (Note A.) A modification of the Riva-Rocci apparatus was used in all estimates of blood pressure in the experiments in this book. The subjects were kept quiet mentally as well as physically, since it was found that mental effort exerted a marked effect upon blood pressure.

Inhibition was secured as follows: The hands of the experimenter were placed under the subject in such a manner that the fingers rested between the transverse processes of the vertebrae to be affected. In this case the eigthth to the tenth thoracic vertebrae were selected. The fingers supported the subject during the experiment. The inhibition lasted for from three to five minutes. The exact time depended upon the information given by the sense of touch of the experimenter. He was able to recognize a change in the tension of the tissues when the inhibition had been effective. (Note B.)

Inhibition Lowers Blood Pressure.

After the inhibition was given the blood pressure was again taken. If the subject were in normal condition, it was invariably found that the inhibition had decreased the blood pressure. In some instances, the fall in pressure amounted to fifteen millimeters of mercury. In others, the fall was less pronounced. An average of the effects observed upon fifteen subjects showed a decrease of eight millimeters of mercury.

This lowered blood pressure was accompanied by a marked feeling of sleepiness on the part of the subject. This sensation made the elimination of psychical effects more easy than it might have been. None of the tests here mentioned were made during sleep, though the subjects often slept after the experiment was concluded. The nature of the reflexes during sleep is being studied in connection with investigations into the physiology of the nervous system. Mental activity was lessened in every instance of decreased blood pressure.

In some instances, the subject, who thought himself normal, was found to suffer from contracted and hypersensitive muscles in the splanchnic region. The inhibition of these areas then relaxed the muscles, and often in these cases the effect of the tratment was to increase the blood pressure. The mechanics of the procedure are evident. The abnormally contracted muscles had been exercising an inhibition for some time, and the mechanical inhibition simply relaxed the muscles and permitted the normal nerve impulses to be unaffected. The rise of blood pressure indicated a return to the condition normal to the individual.

Artificial Lesions.

The artificial lesioon was produced in eight cases. Lesions affecting the tenth thoracic nerves decreased the blood pressure most greatly in all the subjects examined.

Other thoracic lesions produced a variable decrease in the blood pressure. Lesions affecting the twelfth thoracic nerves caused a slight fall of blood pressure, but we were unable to demonstrate any effect directly referable to change in the supra-renal activity by this maneuver.

Stimulation of the Splanchnic Centers.

The effects of splanchnic stimulation upon the blood pressure were then tested. About twenty people were subjects for these tests. The experiment was conducted as in the preceding series. The subject lay quietly upon the treating table until all pulse changes had ceased. The normal resting blood pressure was then taken. Stimulating manipulations were then given in the chosen area. These movements were made by placing the fingers of either hand, or both, over the tissues between the transverse processes of the vertebrae subjcted to experiment, and then making quick, forceful vibratory movements. In this work, also, the sense of touch of the operator is the only test of the efficiency of the movement during the time it is being given. The stimulating movements were given for one or two minutes, according to requirements of the case, as recognized by the occurrence of certain changes in the tissues which are perceptible to the touch but not easily described. The efficient stimulation of the tissues caused them to feel somewhat "toned up," or "more lively," as some operators have expressed it.

The subject usually is unable to recognize in any exact degree the naure of the effects being produced. The effects of stimulation near the tenth thoracic vertebra cause a rise in blood pressure up to twenty millimeters. The average rise of blood pressure so produced is ten millimeters. In every case subjected to experiment by a competent operator, some rise has been observed. Not every operator is able to secure results at the first effort, however.

Stimulation of the tissues near the twelfth thoracic vertebra caused a very great rise in the blood pressure, and also, in almost all of the subjects, a perceptible whitening of the conjunctivae. The force of the heart beat was increased also, but not its rate. These effects were, in the light of the experiments upon animals, referred to an increased secretion of the supra-renals. The effects of this stimulation were more transient than were the effects of the stimulation of the other tissues.

Stimulating manipulations which caused a rise of blood pressure usually caused also a sense of well being, an increase of mental activity, especially of the powers of association, and a sense of alertness. This effect was not very pronounced in some cases, and in a few was not noticeable at all. It is evident that no weight could be given to an answer to a direct question along such lines, so the question was given merely as "How does it make you feel?" or some such question. In many instances the mental effect was the most conspicuous subjective effect of the stimulation.

Stimulation of the tissues near the twelfth caused the greatest rise in blood pdessure, and this stimulation often increased the secretion of urine. In the first experiments, this point was not mentioned, but in later tests, it was found that this effect was produced in nearly all cases.

Stimulation of the tissues near the tenth thoracic seemed to increase peristalsis. This was determined by the sounds heard by the use of the stethoscope. Persons who were subjected to this experiment atferward spoke of an increased hunger and thirst. This increased hunger was noticed in some cases where the subject of the experiment was not quite in a normal condition.

In all cases, the effects of the stimulation were annulled by too long application of the stimulating movements. If the movements were very heavy and were continued for even five minutes, the symptoms of exhaustion of the centers appeared, and the effects were similar to those observed after the production of the artificial lesion.

Superficial Work Inefficient.

Stimulating movements were efficient only when the deeper tissues were affected. Superficial manipulations may produce some effects, even stimulation of the skin alone produced perceptible effects in some cases, but the work which secured the most conspicuous effect was that applied to the tissues between the transverse processes of the vertebrae, and which affected the very articular surfaces of the vertebrae, and, in the thoracic region, the articular surfaces of the ribs.

Note A.—In our investigations in The Pacific College laboratories we found the average blood pressure much lower than is that given in the text books upon physical diagnosis. This is probably due to the character of the climate in Los Angeles. Statistics in text books are compiled in the laboratories of medical and scientific colleges in eastern states, or those of the middle west, where the climate is subject to sudden and ferocious changes. Therefore, the blood pressure is kept very much higher than is needful in this equable climate with its sea-level air pressure.

Note B.—A certain delicacy of touch, acquired only through experience, is essential to the perception of these tissue changes. This delicacy of perception is essential to the success of an osteopath, and every student of osteopathy should begin the education of his touch sense at the very beginning of his course.

CHAPTER XXIX.

THE EXPERIMENTAL DEMONSTRATION OF THE OSTEOPATHIC CENTERS: THE PELVIC VISCERA.

The experiments upon the pelvic viscera are not yet complete. The centers have been fairly well demonstrated, but the pathway of the nerve impulses concerned in the reflexes has not been determined. The following experiments were performed upon animals:

The electrical stimulation of the rectum was followed by contraction of the muscles near the fourth lumbar vertebra and the lumbo-sacral articulation. Stimulation of the anus and urethra caused muscular contractions over the sacrum and along the tail. Sometimes, but not always, the leg muscles were also contracted.

Stimulating manipulations of the tissues near the lumbo-sacral articulation were followed by imperfect movements of defecation, erection, or nicturition. Artificial lesions involving the lower lumbar region caused dilatation of the arterioles of the rectum and bladder and the relaxation of the vesical and anal sphincters.

In all the centers below the second lumbar vertebra the latent period was very much longer than in any other region subjected to experiment. In many of our first experiments we secured no effects whatever from this region. Probably these failures were due to too great haste in ceasing the observations.

Stimulation of the ovaries and testes caused contraction of the muscles near the dorso-lumbar articulation.

BASIC PRINCIPLES.

Stimulation of the Fallopian tubes, or the double uterus, did not cause perceptible muscular contractions in many instances, but in some animals the stimulation of these structures was followed by contractions of the muscles near the second lumbar vertebra. Stimulation of the uterine cervix caused contractions of the muscles near the lumbo-sacral articulation. Stimulation of the lining membranes of the body cavities caused more intense contractions than did the stimulation of their peritoneal coverings.

Stimulating manipulations of the dorso-lumbar tissues caused vaso-constriction of the ovaries. The artificial lesion in this area caused dilatation of the ovarian vessels, as well as the effects described in connection with the abdominal organs.

Stimulating manipulations of the tissues near the second lumbar vertebra produced no perceptible effects upon the structures of the virgin or non-pregnant uterus in the time during which the observations were continued. The latent period is very long in the reactions involving the lumbar segments, and no other significance can be attributed to our failure in this series.

Some of the animals subjected to experiment were found to be in various stages of pregnancy. The following observations were made upon them:

As in virgin and non-pregnant animals, stimulation of the uterine cervix caused muscular contractions near the lumbo-sacral articulation.

Stimulation of the body of the double uterus caused contraction of the muscles near the second lumbar vertebra.

Uterine contractions were never initiated by the anesthesia, nor by manipulations of the uterus, nor by the slight electric currents used for the experiments.

Stimulating manipulations near the second lumbar vertebra caused uterine contractions which were fairly regular, very strong, and continued until the death of the animal. These manipulations alone were accompanied by contraction of the uterine vessels and very great rigidity of the uterine cervix.

Inhibition of the tissues near the lumbo-sacral articulation, or the maintenance of the artificial lesion in this region caused the dilatation of the cervical vessels and relaxation of the cervix. In a few instances, simultaneous stimulation of the tissues near the second lumbar vertebra and inhibition of the tissues near the lumbo-sacral articulation was followed by partial delivery of the first foetus, though the period of pregnancy was not complete, and the animals had been subjected to considerable mutilations of the brain and thorax during a long period of anesthesia.

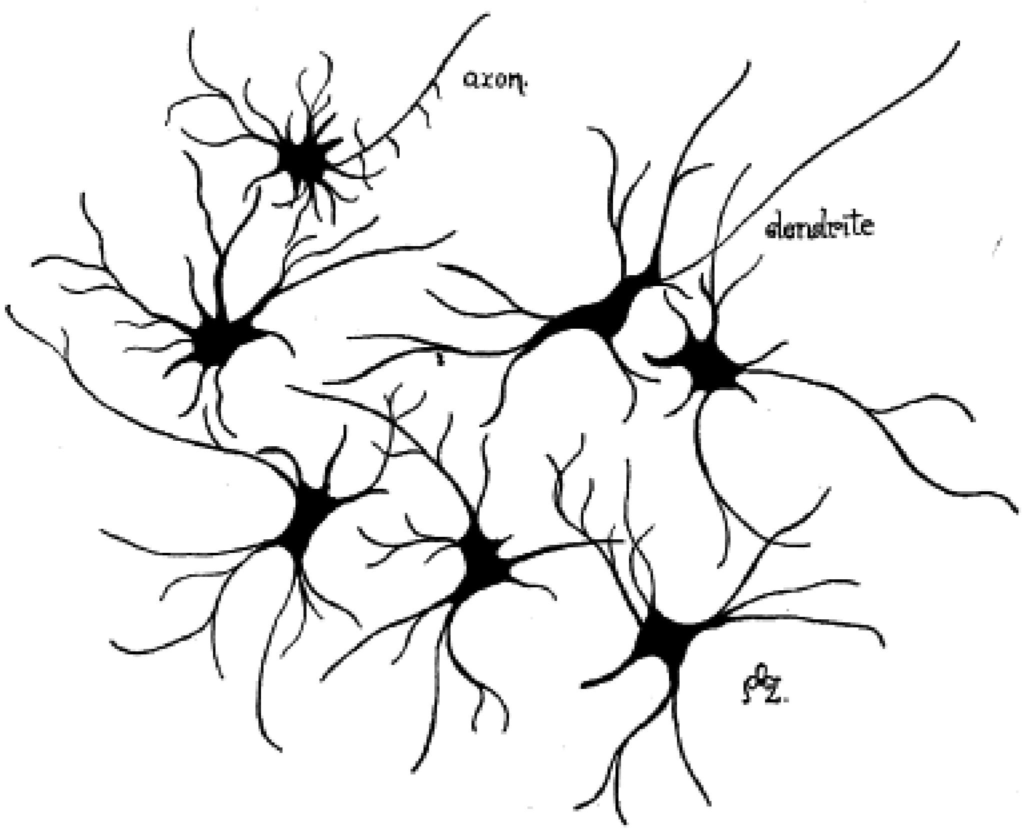

FIGURE 8.

Multipolar cells from the lower triangle of the medulla. Method of Golgi. Objective 2-3 inch.

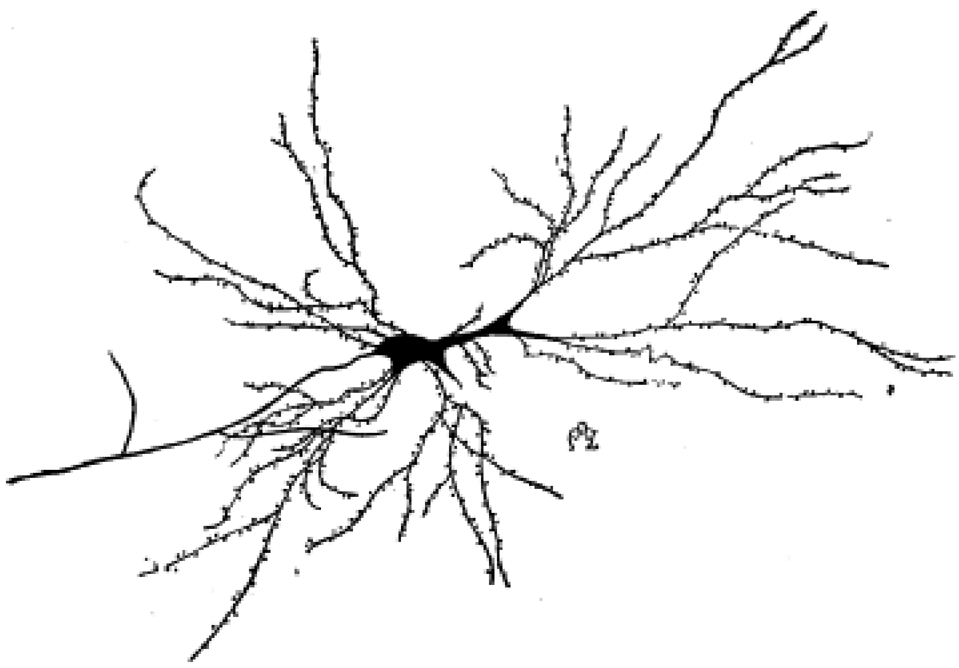

FIGURE 9.

Normal pyramidal cell from the hippocampus major of a half-grown kitten. Method of Golgi. Objective ⅛ inch.

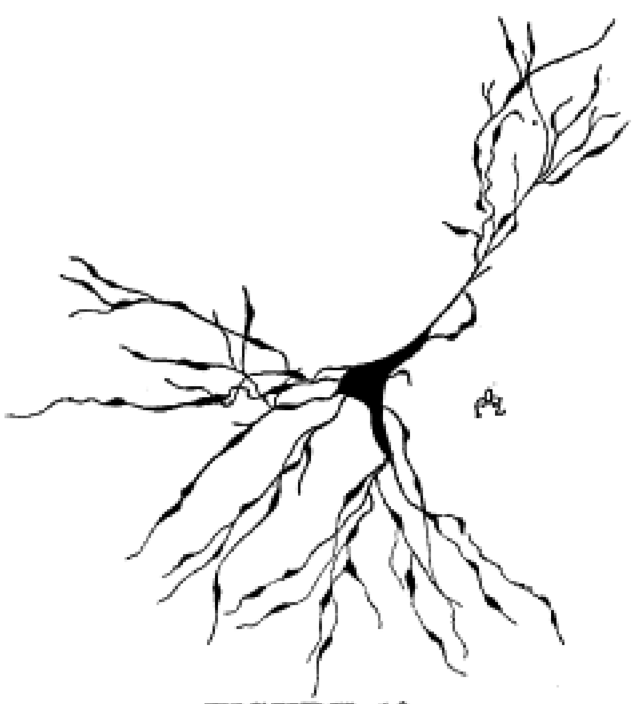

FIGURE 10.

Pyramidal cell from the hippocampus of the opposite side of the brain of the same kitten as that shown in figure 9. This side of the brain was subjected to urgent stimulation after the removal of other hemisphere. The changes due to the stimulation are shown in the swollen and irregular dendrites, and the absence of the normal gemmules. Objective ⅛ inch.

GLOSSARY.

Ad-apt-a′-tion—The process by means of which any organism becomes fitted for a new environment or function.

Ag-glu′-tin-ins—Substances in the blood serum which cause the clumping of bacteria. They are found in great dilution in other body fluids, also.

Al′-ien-ism—Any abnormal mental condition.

Am-bo-cept′-or—A receptor which has been set free from a cell; it contains two haptophore groups.

An-ab′-ol-ism—The process of building food materials into living protoplasm or into functional parts of the cell.

Al-ex′-in, or Al-ex′-ine—The bactericidal or bacteriolytic substances dissolved in the serum and other body fluids.

At′-a-vism—The appearance in an individual of structural or functional peculiarities characteristic of the race at an earlier stage of development.

Aut′-o - in-tox-i-ca′-tion—Poisoning by the retention of the waste products of metabolism, either normal or abnormal.

Ax′-on—One of the processes of the neuron, distinguished from the other processes, the dentrites, by the following characteristics: The axon arises from an axon hillock, contains no tigroid substance, gives off branches at right or recurrent angles, always carries impulses away from the cell body, and terminates by forming synapses with other neurons or in a motor nerve ending. (Figures 3, 8, 9.)

Ax′-on Hil′-lock, or Implantation Cone—A clear portion of the protoplasm of the neuron from which the axon arises. It contains no tigroid substance, and resembles the axon in its staining reactions. (Figure 3.)

Bac-ter-i-ci′-dal—Having the power of killing bacteria.

Bac-ter-i-o-lyt′-ic—Having the power of dissolving bacteria. Used also as a synonym of bactericidal.

Ba′-sal Gang′-lia—Collections of neurons arranged around the lower part of the cerebral hemispheres, wherein are co-ordinated the impulses concerned in the emotional reactions. The optic thalamus, the corpora striata, the red nucleus, the substantia nigra, and the sub-thalamic region are included with others in the term.

Bi′-o-gen—The living proteid molecule.

Cen′-ter, Nerve—A group of neurons which receive and co-ordinate the impulses regulating the activity of any organ or controlling any function. The nerve centers act in accordance with the algebraic sum of the impulses reaching them. Morat is authority for the statement that neurons may be affected by nerve impulses which retard or inhibit their activity.

Cen′-ter, Os-te-o-path′-ic, or Su-per-fic′-ial—Certain areas upon the surface of the body whose sensory nerves affect the action of the nerve centers.

Cen′-ter, Speech—The group of neurons in the third frontal convolution which co-ordinate the impulses from the sensory and associational neurons concerned in speech.

Cen′-ters, Vas′-o - mo′-tor—Groups of neurons in the spinal cord, the floor of the fourth ventricle and the acqueduct of Sylvius, which co-ordinate the impulses from the associational and sensory neurons concerned in regulating the size of the blood vessels.

Cen′-ters, Vis′-cer-o - mo′-tor—Groups of neurons which receive and co-ordinate the impulses concerned in regulating visceral activties.

Ceph-al-i-za′-tion—The headward tendency noted in animals, especially in vertebrates. The grouping of important organs in or near the head. The process of cephalization is incomplete in the degree in which segmentation remains dominant.

Chem-o-tax′-is—The movement of cells toward or from the source of substances in solution.

Chro-ma-tol′-y-sis—The disintegration of the tigroid substance. Varying degrees of chromatolysis occur normally under the influence of stimulation. Abnormally, chromatolysis occurs under the influence of many poisons, excessive fatigue, hyperpyrexia, senility and star vation. Recovery is not impossible even after very marked chromatolysis.

Chro′-mo-somes—The stainable rods which result from the breaking of the spireme in karyokinesis. They are invariable in number for any given species of animal or plant, except for the reproductive cells after maturation and before conjugation. They are held to be the bearers of the hereditary qualities.

Col-lat′-er-al—A branch given off by an axon. Collaterals leave the axon at right or recurrent angles. By means of collaterals, a neuron is able to affect the action of more than one other neuron. (Figures 8, 9.)

Cy′-tase—A ferment which is able to destroy cells.

Death—The cessation of the co-ordinate processes whose sum makes life. Normally, the expiration of the possibilities of metabolism in the absence of sexual reproduction. The cells of complex bodies are unable to undergo sexual division, hence death is inevitable to these. Abnormally, death is the result of inability to maintain metabolism in the presence of an abnormal environment, or of some structural injury.

Den′-drite—One of the prolongations of a neuron, distinguished from an axon by the following characteristics:

Dendrites may be of almost any number; they contain Nissl's bodies; their protoplasm has the staining reaction of the cell protoplasm; they branch at acute angles, as do trees, whence their name. Dendrites carry impulses toward the body of the neuron. With the exception of the sensory neurons of the first order, dentrites are usually short, and decrease regularly in size from their origin to their termination. Dendrites probably also assist in the nutrition of the neuron by increasing the amount of absorptive surface. (Figures 3, 8, 9, 10.)

Di-ag-no′-sis—The recognition of abnormalities of structure, environment, or habit which are responsible for disease or mal-function.

Dis′-ease—The existence of an abnormal relation between any cell, or cell group, or organ, or system of organs, with their environment or with one another.

En′-zyme—A substance, or ferment, produced by cell activity which is capable of causing or facilitating chemical reactions. These substances are characterized by the following qualities:

They act best in their optimum temperature.

They act only upon the substances to which they are adapted.

Their activity ceases in the presence of any considerable quantity of the products of their activity.

They appear to act by catalysis; that is, they cause or hasten the reaction without themselves becoming a part of the final product.

The amount of change which can be produced by a given amount of an enzyme is out of all proportion to the amount of the enzyme present. See Ferment and Zymogen.

Eu-than-as′-ia—Painless death, or normal death. The word is sometimes not quite properly employed in reference to the use of anesthetics to render death speedy and painless.

En-vir′-on-ment—The sum of all the factors which influence any living organism. Among the lower animals and plants, the environment is limited to factors in actual contact with the living matter. Among higher animals, the sense organs increase the environment greatly. By the activity of the powers of associative memory the environment of the human race includes all of the past whose history is known, and all of the future to which the past gives a clue.

Ex-haus′-tion—The condition of any cell or group of cells whose reserves of potential energy have been used. Exhaustion differs from fatigue in this, that fatigue refers rather to the accumulation of the katabolic products, while exhaustion refers to the depletion of the materials necessary for anabolism. See Fatigue.

Fa-tigue′—The effects produced by over stimulation. The term is properly limited to the excessive accumulation of katabolic products. See Exhaustion.

Fer′-ment, Organized—Cells which have the power of causing or facilitating chemical reactions in the substances found in their environment. Example, yeast, certain bacteria.

Ferment, Unorganized—Certain products of cell activity, themselves apparently not living, which have the power of causing or facilitating chemical reactions. Example, pepsin, trypsin, rennin, etc. See Enzyme.

Fix′-a-tives—Side chains, probably discarded receptors, able to unite with and render inert bacteria, toxins, or foreign blood cells. These are supposed to be produced in great numbers in acquired immunity, and it is to their presence in the blood stream that immunity is supposed to be due.

Func′-tion—The manner of the action of any living structure. The place of any part of an organism in its metabolism.

Gang′-lion—A group of neurons associated in structure and in function.

Gang′-lion, Sympathetic—A group of neurons situated in any of the body cavities and distinguished from other nerve collections by the following characteristics:

Sympathetic axons are not medullated, or have very small and inconspicuous sheaths.

Sympathetic axons are distributed to non-striated muscles, cardiac muscles, and glands.

Sympathetic neurons are governed by impulses from the viscero-motor centers in the cord, medulla, pons and mid-brain.

Gang′-lion, Ba′-sal—Certain groups of neurons arranged around the base of the brain, wherein are co-ordinated the impulses concerned in the emotional reactions.

Gang′-lion, Sens′-ory—Groups of neurons whose bodies lie in the inter-vertebral foramina, in the cranial foramina and the cranial cavity, and in the middle ear, whose axons enter the cord, the medulla or the pons, and whose dendrites terminate in sensory nerve endings.

Hab′-it—The performance of actions under the influence of similar actions performed in the past. Cellular memory.

Hap′-to-phore—The part of a side chain which contains groups having free valencies.

Health—That relation of organism and environment which renders the organism capable of gaining the most energy from the environment, and of making the reply to environal changes which makes for the best good of the organism itself and its race.

He′-lot-ism—(from Helot, one of a race of slaves)—A manner of living together of two different organisms wherein one receives the chief benefit, and the other receives only the necessaries of existence. The chlorophyll bodies in algae are examples of this condition. These live within the alga cells, and make starch for the food of the host.

He′-mat-o-poi-et′-ic—Blood forming.

Hematopoietic Organs—The organs concerned in the manufacture of the erythrocytes. In the adult, these are mostly limited to the red bone marrow; in the embryo, many of the glands of the body are hemotopoietic.

Her-ed′-i-ty—The transmission of characteristics from one generation to another by means of cell structure or habit. The transmission of characteristics from one generation to another by means of education or nutritive conditions is not properly termed heredity.

Hy′-dranth—The blossom shaped expansion at the summit of the stem of hydroidea, etc., by means of which food is taken.

Im-mu′-ni-ty—The condition of being unaffected by bacterial or parasitic invasion, or by poisons. The term is usually applied to freedom from successful bacterial invasion.

Im-mu′-ni-ty, Ac′-quired—The immunity which follows recovery from bacterial invasion, or repeated non-lethal doses of poisons or toxins.

Im-mu′-ni-ty, Ab′-so-lute—The condition of an organism whose invasion by any given bacterium is impossible.

Im-mu′-ni-ty, Nat′-ur-al—The immunity which depends upon the absence of receptors capable of forming chemical union with the molecules of any given bacterium. That is, since every cell maintains its own characteristic metabolism, there must be variations in the nature of the side chains of its biogens; and these must vary in their affinities, as chemical compounds differ from one another in their affinities. If any cell maintains a manner of metabolism which is associated with the presence of side chains which have absolutely no affinity for a given toxin or bacterial product, that cell enjoys natural immunity.

Im-plant-a′-tion Cone—See Axon Hillock.

Im′-pulse (from the word meaning "impel")—The change, or series of changes, produced in the entire neuron by a change in the environment of any of its parts, and which it transfers to other neurons or to other tissues.

In-her′-it-ance—The sum of the traits which any organism receives from its progenitors by way of cell structure or function. Inheritance is evidently carried by the chromosomes.

I′-on—(from the word meaning "to go")—One of the atoms or radicals into which compounds are divided by an electrical current, or in very dilute solutions.

Kar′-y-o-kin-e′-sis—The series of nuclear changes which initiate and accompany cell division. Among nearly all forms of cell life, cell division is karyokinetic, and the number of cells which appear to undergo direct or akinetic division is becoming continually smaller as our methods of investigating the phenomena of cell life becomes more exact and exhaustive. The process of karyokinesis, which is very complex, is fully decribed in

"The Cell," by E. B. Wilson.

Kar′-y-o-kin-et′-ic—Pertaining to karyokinesis.

Ka-tab′-ol-ism—The destructive aspect of metabolism. The sum of the processes by means of which the complex compounds of the living protoplasm are broken into the waste products which are eliminated from the cell.

Kat-a-bol′-ic—Pertaining to, or characteristic of, katabolism.

Ky′-mo-graph, or Ky-mo-graph′-ion—An instrument for recording the movements of a needle. It consists of a clock which carries a revolving drum which is covered with smoked paper. A needle playing upon the smoked surface leaves a white mark. The record thus made is rendered permanent by being coated with shellac or some other varnish. The tracing of the respiratory movements illustrated in Figures 4 and 5 were made by the kymograph.

Le′-sion—The structural abnormality which is responsible for functional derangement. Any change is the structure or relationship of tissues which produces abnormal metabolic changes.

Le′-sion, Bony—Used in a somewhat restricted sense in reference to the slight mal-positions of bones, or to bones held fixed in a position which brings tension upon their articular surfaces, and thus initiates reflex visceral mal-function.

Lesion, Mus′-cu-lar—Used as above, in reference to contractures or to the maintenance of muscular contraction for a length of time abnormal to the muscles.

Lesion, Vis′-cer-al—Structural abnormality of viscera.

Lesion, Cer′-e-bral—Structural changes in the cerebral substance.

Life—A term not to be exactly defined. The characteristic of certain complex compounds by means of which they are able to make use of environal changes as a source of energy and to transform environal substances into the form of their own molecules.

Lim′-inal Val′-ue—See Neuron Threshold.

Mat-ur-a′-tion—The process of cell division by means of which the number of chromosomes in the ovum and sperm cells is halved in preparation for conjugation.

Met′-a-zo′-a—Animals whose bodies are composed of many cells.

Met-ab′-ol-ism—The series of chemical reactions by means of which the cell assimilates food from its environment and transforms these again into its own wastes.

Mod-i-fi′-a-ble—That characteristic of cells by means of which the nature of their reply to environal changes varies according to previous reactions.

Neu′-ron—A nerve cell with all its prolongations, the entire cell.

Neu′-ron, Sensory, of the First Order—A neuron which is affected by environal changes, transforms the effects of these into nerve impulses, and conveys the nerve impulses to the central system. The dendrite of a sensory neuron of the first order terminates in a sensory nerve ending.

Of the Second Order—Neurons which receive impulses from those of the first order. Neurons of the third order receive impulses from these, and so on.

Neu′-ron, Mo′-tor, of the First Order—A neuron which carries nerve impulses to muscles. Its axon terminates in a motor nerve ending.

Of the Second Order—Neurons which transmit impulses to the motor neurons of the first order. Motor neurons of the third order transmit impulses to these, and so on.

Neu′-ron, Sym-path-et′-ic—A neuron whose cell body lies in a sympathetic ganglion. Its dendrites intermingle with the terminal ramifications of the axons from the white rami, receiving impulses from them. Its axon terminates upon the visceral and vascular muscles and among gland cells. (Figures 2 and 3.)

Neu′-ron Threshold—The least amount of stimulation which is sufficient to initiate a nerve impulse. This varies for different neurons and for the same neuron at different times. The neuron threshold is normally lowered by the frequent activity of the neuron. It is abnormally lowered by fatigue, certain poisons, and by a slight increase in temperature.

Neu′-ron Sys′-tem—A group of neurons associated for the performance of any function.

Neu-ro′-sis—A rather indeterminate term, referring to any group of symptoms which result from mal-function of the central nervous ssytem.

Nissl's Bodies—See Tigroid Substance.

On-tog′-en-y—The development of the individual. The history of the growth changes from the single cell to the adult organism.

On′-to-gen-et′-ic—Pertaining to Ontogeny.

Op′-son-ins—Substances found in the serum which so affect the bacteria as to render them susceptible to phagocytosis. The same substances are called fixatives, fixators, sensibilizing substance.

Op-son′-ic In′-dex—The number and power of the opsonins present in any given blood proportionate to an empirical standard.

Or-i-en-ta′-tion—The changes in the attitude or movements of an organism which are produced by the effect of external stimulation. For example, the turning of a moth toward the light.

Os-mo′-sis—That passage of liquids or of substances in solution through membranes which depends upon the relative number of molecules present upon the sides of the membrane. A very concise explanation of the physiological aspect of osmosis is given in Howell's Text Book of Physiology.

Os-mot′-ic—Pertaining to osmosis.

Path-o-gen′-ic—Capable of causing structural or functional abnormality.

Phag′-o-cyte—Literally, an eating cell. A white blood corpuscle which ingests foreign substances.

Phag-o-cy-to′-sis—The action of phagocytes in ingesting bacteria or other foreign substances. Certain other mesoblastic cells seem to perform this function also, at times.

Phy-log′-e-ny—The series of developmental steps by means of which any race or species has attained its present structure and function.

Phy-lo-ge-net′-ic—Pertaining to phylogeny.

Pleth-ys′-mo-graph—An instrument for recording the changes in the size of an organ, usually the hand. It consists of a glass cylinder provided with three stop cocks with rubber tubes. Two of the tubes are used for filling and empting the plethysmograph, the other is connected with a tambour, q. v. The hand is enclosed in the cylinder and the arm surrounded by a rubber cuff. The plethysmograph, tubes and tambour are filled with water, oil, etc., and the needle of the tambour plays upon the kymograph drum. Any increase in the amount of blood in the hand increases the size of the hand, presses the liquid from the cylinder into the tambour, and causes the needle to rise. This traces its movement upon kymograph paper, and the record may be preserved. By means of this instrument changes in the blood flow produced by manipulations of the osteopathic centers may be demonstrated.

Pre-cip′-it-ins—Substances in the blood serum which precipitate the serum of other animals or the filtrate of bacterial cultures.

Pro′-to-zo′-a—Animals which are unicellular in adult life.

Psy-cho′-sis—Any abnormal condition of the cerebral cortex which exerts a perceptible effect upon mental processes.

Re-cept′-ors—The side chains which have free valencies for food stuffs and which may be affected by toxins, etc. Injured receptors are replaced by the cell, apparently in numbers in excess of the number injured. These produced in excess may be cast off from the cell, and are supposed to be concerned in acquired immunity.

Re′-flex—An action produced by efferent nerve impulses which result from incoming sensory impulses without the intermediation of consciousness. (Figures 1 and 2.)

Re′-flex, So-mat′-ic—Activity of skeletal muscles in answer to the stimulation of somato-sensory nerves.

Re′-flex, Vis′-cer-al—Activity of visceral or vascular muscles or glands caused by the stimulation of viscero-sensory nerves.

Re′-flex, Vis′-cer-o - somat′-ic—A contraction of skeletal muscles resulting from the stimulation of viscero-sensory nerves.

Re′-flex, So′-mat-o - vis′-cer-al—Activity of visceral or vascular muscles or glands resulting from the stimulation of somato-sensory nerves.

Re-gen-er-a′-tion—The process of renewing injured or lost parts. Example, the snail reproduces a new eye stalk if the old one is removed.

Seg′-ment (of the spinal cord)—That part of the cord included between the uppermost fibers of one nerve root and the uppermost fibers of the root next below.

Side Chains—Radicals of the living proteid molecule which are attached to the central group and which serve some function in the series of chemical changes whose sum is the function of that molecule.

So′-mat-o - mo′-tor—Pertaining to efferent impulses to the skeletal muscles.

So′-mat-o - sens′-ory—Pertaining to the afferent impulses from the skeletal structures.

So-mat′-ic—Pertaining to skeletal structures, as distinguished from visceral structures. Sometimes used as pertaining to the tissues of the individual body, as distinguished from the reproductive cells.

Sphyg′-mo-man-om′-e-ter—An instrument for measuring blood pressure. It consists of a cuff made of a rubber bag, connected by a rubber tube with a mercury manometer and a small air pump. The cuff is placed around the arm over the biceps. The cuff is then filled with air by means of the pump and the pressure increased until the pulse is no longer perceptible. The pressure is continuous in the cuff and in the chamber of the manometer, and the height of the mercury in the tube indicates the pressure in the radial artery.

Sphyg′-mo-graph—An instrument for registering the pulse wave. It consists essentially of a lever which rests upon the pulse, and which supports a needle which plays upon a strip of smoked paper. The paper is fed regularly into the machine by clock work. The tracings shown in Figures 6 and 7 were made with Dudgeon's sphygmograph.

Sphyg′-mo-graph—The tracing made by a sphygmograph. (Figures 6 and 7.)

Star-va′-tion—The condition of being without the essentials of life, usually referring to food.

Stim-u-la′-tion—Any change in the environment which causes a change in the metabolism of an organ.

Struct′-ure—The form of an organism, as distinguished from its function.

Sub-dis-lo-ca′-tion—See Subluxation.

Sub-lux-a′-tion—A slight mal-adjustment of bones. In subluxation there is no separation of the articular surfaces, but the joints are held in a position of tension, either by contracted or contractured muscles, or by ligaments which are abnormally shortened, thickened or lengthened.

Sum-ma′-tion—The accumulation of stimuli. That is, an inefficient stimulus may be frequently repeated at short intervals and the effects accumulate in an organism until their sum is efficient and the reaction may occur.

Sym-bi-o′-sis—The living together of two distinct organisms to their mutual advantage. See Helotism.

Sym-pa-thet′-ic - Ganglion—See Ganglion, Sympathetic.

Symp′-tom—Any perceptible deviation from normal activity.

Syn-ap′sis—The structural relation between neurons which makes their functional relation possible. This structural relation is secured by different modes of connection. The synapsis always occurs between the axon or collaterals of one cell and the dendrites or the cell body of another. The manner of the synapsis of the fibers of the white rami with the sympathetic ganglion cells is shown in Figure 3. The axons of the olfactory nerves branch among the dendrites of the mitral cells of the olfactory lobe in the structures called glomeruli. The axons of the basket cells of the cerebellum form basket-like networks around the bodies of the Purkinje cells. The climbing fibers of the cerebellum branch among the dendrites of the Purkinje cells. The collaterals from the incoming axons of the sensory roots of the cord simply branch among the dendrites of the cells of the anterior and lateral horns. Other methods of synapsis are recognized.

Tam′-bour—An instrument of precision for recording changes in the size or motion of organs. It consists of a pan, covered with rubber sheeting, and tubing by means of which connection with another pan, or with the plethysmograph, manometer, etc. The rubber sheet supports a needle which plays upon the revolving drum of a kymograph. The tracings in Figures 4 and 5 were made by Marey's tambour, with the second pan also covered with a rubber sheet and placed over the apex beat of the heart.

Ti-groid′ Sub′-stance, or Niss′-l's Substance, or Bodies—Masses of nuclear substance found in the meshes of the neuron protoplasm which appear after certain methods of fixation and staining. These masses are found in the normal neuron, but undergo characteristic changes during stimulation, or in the presence of temperature changes or poisoning. (Figure 3.)

Tox′-ins—Poisonous substances formed by bacteria or other parasites, or by cells abnormal to the body, or by cells normal to the body but suffering from abnormal conditions.

Tox-e′-mia—The presence of toxins in the blood.

Vis′-cer-o - mo′-tor—Pertaining to the efferent impulses to the visceral muscles and glands.

Vis′-cer-o - sens′-or-y—Pertaining to the afferent impulses from the viscera.

Vas′-o - mo′-tor—Pertaining to the efferent impulses to the muscles of walls of the blood vessels.

Zym′-o-gen—The substances which are the precursors of the enzymes. For example, Trypsin is made from trypsinogen, pepsin from pepsinogen, etc. The zymogens remain within the cell awaiting the stimulation which shall initiate their transformation into the enzymes, which, being soluble, pass through the cell wall into the body fluids, and become functional.

BIBLIOGRAPHY.

The following books and papers were consulted in the preparation of this volume. The list does not offer a complete bibliography upon any subject:

Allen, B. M.—The Embryonic Development of the Ovary and Testis of the Mammals, The American Journal of Anatomy, vol. III, No. 2.

Barker, L. F.—The Nervous System and Its Constituent Neurons.

Benedict, S. R.—The Role of Certain Ions in Rhythmic Heart Activity, The American Journal of Physiology, vol. No. 3.

Bliss, Pearl A.—The Vaso-Motor Nerves in the Lungs A. O.

Booth, E. R.—A History of Osteopathy.

A. Journal, August, 1907.

Bullot, G.—On the Swelling of Organic Tissues, The American Journal of Physiology, vol. XII, No. 3.

Burns, L.—The Metabolism of the Neuron, Bulletin of the Southern California Academy of Sciences, May, 1905.

Blood Pressure and Flatulence. A. O. A. Journal, April, 1907.

Partial Report of Experiments Upon Visceral Reflexes, The Osteopathic World, August, 1905.

Carlson, A. J.—Changes in the Nissl's Substance of Cells of Retina—During Prolonged Stimulation, The American Journal of Anatomy, vol. II, No. 3.

Castle, W. E.—Heredity of Coat Characters in Guinea Pigs and Rabbits. Publication No. 23, Carnegie Institution of Washington.

Clark, M. E.—Osteopathic Gynecology.
Applied Anatomy.

Clements, F. E.—Research Methods in Ecology.

Coriat, I. H.—A Review of Some Recent Literature on the Chemistry of the Central Nervous System, The Journal of Comparative Neurology and Psychology, vol. XV, No. 2.

Darwin, Charles—Descent of Man.
Plants and Animals Under Domestication.

Davenport, C. B.—Experimental Morphology, vols. I and II.

Davis, N. S.—A History of Medicine.

DeVries, Hugo—Intracellular Pangenesis.
Species and Varieties.

Edinger, Ludwig—The Anatomy of the Central Nervous System in Man.

Emery, R. D.—Studies of Foods, The Osteopath, January, 1901.

Fay, E. A.—Marriages of the Deaf in America.

Goldthwait, J. E.—A Study of the Metabolism in Osteomalacia. The American Journal of Physiology, vol. XIV, No. 5.

Gordinier, H. C.—The Gross and Minute Anatomy of the Central Nervous System.

Gulick, J. T.—Evolution, Racial and Habitudinal, Publication 25, Carnegie Institution of Washington.

Haig, Alexander—Uric Acid.

Halliburton, W. D.—Biochemistry of Muscle and Nerve.

Hatai, Shinkishi—The Excretion of Nitrogen by the White Rat as Affected by Age and Body Weight, The American Journal of Physiology, vol. XIV, No. 2.

Hazzard, Charles—Principles of Osteopathy.
Practice of Osteopathy.

Henderson, Yandell—Observation on the Fate of Oil Injected Subcutaneously. The American Journal of Physiology, vol. XIV, No. 3.

The Mass-Movements of the Circulation as Shown by a Recoil Curve. ibid vol. XIV, No. 3.

Herrick, C. L.—The Beginning of Social Reactions in Man and Lower Animals. Journal of Comparative Neurology and Psychology, vol. XIV, No. 2.

Herter, C. A.—On the Reducing Action of the Animal Organism Under the Influence of Cold. The American Journal of Physiology, vol. XII, No. 1.

The Influence of Fever on the Reducing on the Reducing Action of the Animal Organism. ibid vol. XII, No. 5.

Hertwig, Oscar—The Cell.

Hulett, G. D.—Principles of Osteopathy.

Hyde, Ida H.—Differences in the Electrical Potential in Developing Eggs. The American Journal of Physiology, vol. XII, No. 3.

A Reflex Respiratory Center. The Journal of comparative Neurology and Psychology, vol. XVI, No. 3.

Jennings, H. S.—Reactions to Heat and Cold in the Ciliate Infusoria.

Reactions to Light in the Ciliates and Flagellates.

Reactions to Stimuli in Certain Rotifera.

The Theory of Tropisms.

Physiological States as Determining Factors in the Behaviour of the Lower Organisms.

The Movements and Reactions of Amoeba.

The Method of Trial and Error in the Behaviour of Lower Organisms.

Johnston, L. B.—The Nervous System of Vertebrates.

Jordan, D. S.—Foot-Notes to Evolution.

Koch, Waldeman—The Lecithans, Decennial Publications, The University of Chicago.

Leathes, J. B.—Problems in Animal Metabolism.

Levene, P. A.—The Autolysis of Animal Organism. The American Journal of Physiology, vol. XI, No. 3.
On the Combined Action of Proteolytic Enzymes, ibid vol. XII, No. 1.

Lillie, R. S.—The Physiology of Cell Division, ibid., vol. XV, No. 1.

Lingle, D. J.—Restorers of the Cardiac Rhythm, ibid., vol. 5.

Littlejohn, J. M.—Physiology, Exhaustive and Practical.
Psycho-Physiology.
Psycho-Pathology.
Cancer. A. O. A. Journal, March, April and May, 1907.

Loeb, Jacques—The Dynamics of Living Matter.
Studies in General Physiology.
Physiology of the Brain.

Loesser, William—A Study of the Functions of the Different Parts of the Frog's Brain. The Journal of Comparative Neurology and Psychology, vol. XV, No. 5.

Lovett, R. W.—A Contribution to the Mechanics of the Spine. The American Journal of Anatomy, vol. II, No. 4.

Martin, E. G.—An Experimental Study of the Rhythmic Activity of Isolated Strips of Heart Muscles. The American Journal of Physiology, vol. XI, No. 2.

McConnell, C. P., and Teall, C. C.—Practice of Osteopathy.
TheOsteopathic Lesion. A. O. A. Journal, September and December, 1905, and May and August, 1906.

McCrudden, F. H.—A Study of the Metabolism in Osteomalacia. The American Journal of Physiology, vol. XIV, No. 5.

The Effects of Castration on the Metabolism in Osteomalacia, ibid., vol. XVII, No. 3.

McMurrich, J. P.—The Development of the Human Body.

Meigs, E. B.—A Mechanical Theory of Muscular Contraction, and Some New Facts Supporting It. American Journal of Physiology, vol. XIV, No. 2.

Mendell, L. B.—On the Utilization of Various Carbohydrates Without the Intervention of the Alimentary Digestive Processes. The American Journal of Physiology, vol. XIV, No. 3.

On the Paths of Absorption from the Liver, ibid., vol. XIV, No. 3.

On the Absorption and Utilization of Proteids Without Intervention of the Alimentary Digestive Processes, ibid., vol. XII, No. 4.

On the Intermediate Metabolism of the Purin-bodies, ibid., vol. XII, No. 1.

A Reflex Respiratory Center. The Journal of Com-

Metchnikoff, Elie—Immunity in Infectious Diseases.

Minot, C. S.—Human Embryology.

Genetic Interpretations in the Domain of Anatomy. The American Journal of Anatomy, vol. IV, No. 2.

Mitchell, P. H.—On the Utilization of Various Carbohydrates Without the Intervention of the Ailmentary Digestive Processes. The American Journal of Physiology, vol. XIV, No. 3.

Morat, J. P.—Physiology of the Nervous System.

Morgan, T. H.—Regeneration.

Neilson, C. H.—Similarity between Catalysis and Enzyme Action. The American Journal of Physiology, vol. XV, Nos. 2 and 4.

Osgood, R. B.—A Study of the Metabolism in Osteomalacia, ibid., vol. XIV, No. 5.

Painter, C. F.—With Osgood, ibid.

Packard, W. H.—On Resistance to a Lack of Oxygen. The American Journal of Physiology, vol. XV, No. 1.

Pierce, J. J.—Some Visceral Actions Obtained by Manipulation of Cerebro-Spinal Nerves. Report of Osteopathic Association of the State of California, 1905.

Ricketts, H. T.—Infection, Immunity and Serum Therapy.

Robinson, Byron—The Abdominal Brain.

Schryver, S. B.—Chemistry of the Albumens.

Stevens, N. M.—Studies in Spermatogenesis. Publication No. 36, Carnegie Institution of Washington.

Still, A. T.—Autobiography.

Philosophy of Osteopathy.

The Philosophy and Mechanical Principles of Osteopathy.

Stookey, L. B.—On the Combined Action of the Proteolytic Enzymes. The American Journal of Physiology, vol. XII, No. 1.

Tasker, D. L.—Principles of Osteopathy.

Pulse Tracings. The Osteopath, August, 1901.

Towle, Elizabeth W.—A Study of the Effects of Certain Stimuli. The American Journal of Physiology, vol. XII, No. 2.

Vernon, H. M.—Variations in Plants and Animals.

Verworn, Max—General Physiology.

Wallace, A. R.—On Natural Selection.

Wells, Gideon—On the Relation of Autolysis to Proteid Metabolism. The American Journal of Physiology, vol. XI, No. 4.

Weismann, August—Essays on Heredity.

The Germ Plasm.

Whitman, C. O.—Evolution and Epigenesis.

Whiting, C. A.—The Value of Laboratory Diagnosis. Report of the Osteopathic Association of the State of California, 1903.

The Place of Blood Examinations in the Diagnosis of Disease, ibid., 1905.

The Human Brain. The Osteopath, March, 1900.

The Spinal Cord, ibid., January, 1901, January, 1902.

The Purin Bodies. A. O. A. Journal, August, 1905.

A Dermoid Cyst. Bulletin of the Southern California Academy of Science, February, 1905.

Wiedersheim, Robert—Comparative Anatomy of Vertebrates.

Wilson, E. B.—The Cell in Development and Inheritance.

Fertilization and Karyokinesis of the Ovum.

Wood, F. A.—Mental and Moral Heredity in Royalty.

Woodall,—Osteopathic Gynecology.

Yerkes, Ada W.—Modifiability of Behaviour in Hydroides dianthus V. The Journal of Comparative Neurology and Psychology, vol. XVI, No. 6.

Text Books in Pathology—Martin, McConnell, Thayer, Delafield and Prudden, Coplin, McFarland.

Text Books in Physiology—Landois, Kirke, Tigerstedt, Howell, Raymond, Ott, Foster, Littlejohn, Brubaker and the American Text Book.

Text Books of Medical Practice—Osler, Tyson, Thayer, Taylor.

Text Books on Mental Diseases and Defectives and Nervous Diseases—Barr, Brower and Bannister, Church and Peterson, Dana, Crothers, Allchin, Berkley, Hirt.

Text Books on Hematology—Cabot, Da Costa.

Periodicals—Journal of the American Osteopathic Association, 1903, 1907. Osteopathic World, 1903-1905. The American Medical Association, 1900-1907. The Medi-American Osteopath, 1902-1907. The Journal of the cal Record, 1902-1907.

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