PRINCIPLES OF POSTURE, WITH SPECIAL REFERENCE TO THE MECHANICS OF THE HIP-JOINT.

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SECOND PAPER

IN the previous paper* the mechanics of the body were discussed from the standpoint of the distribution of the weight of the bones of the body in relation to the median line of the structure. It was demonstrated that when the median line of the structure passed through the center of each of the units of weight, the structure would be maintained with the least possible strain between its various parts; and the muscles, therefore, would have the greatest freedom for movement. This law is universally applied in the world of mechanics, where the weight of the articulated parts of a mechanism is so adjusted as to facilitate freedom of movement with the minimum of wear and tear. When the human structure is governed by this law of balance, there will be an equality of pressure between all articulating bony contacts and weight will be maintained at center with the least expenditure of muscular and nervous energy.

The points to be discussed in this paper are:

I. The Balance of the Principle Units of Weight in Relation to the Whole;

II. The Interdependence of the Various Units; and

III. The Significance of Normal Mechanics of the Hip-Joint, at Rest and in Motion.

THE BALANCE OF STRUCTURAL WEIGHT IN RELATION TO THE MEDIAN LINE.

In considering this point, we note that every articulated structure must have a median line. That line may be either the mean line of the weight of the articulated groups, or the mean line of resistance between the articulated units of weight, in which each unit is being held away from center, or out of alignment. The following drawing illustrates this point: Figure I, line *a*, indicates the median line of weight of articulated groups, or equilibrium of the mass. Figure II, line *a*, indicates the degree of resistance between the units of weight, *b*, *c*, *d*.

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FIG. I.

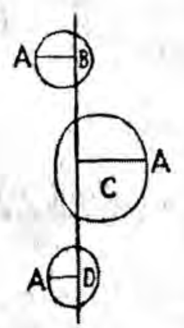

FIG. II.

It matters not whether the motive power of the mechanism comes from within or without, the above law is operative under all conditions. The motive power may be steam, electricity, or nerve energy, the operation of this law must be considered in each case, if conservation of power is to be attained. In studying the mechanics of the human structure, the problem is to find the similarities of the functioning of the anatomical parts in relation to this mechanical principle.

With the principal units of weight of a structure in perfect alignment, there would be entire freedom of action in all the flexible parts. The main function of the bony structure is to support the weight of the body. The bones, being the most inert substance of the human structure, should be maintained in such equilibrium as will require the least possible muscular effort for maintenance of weight, and thus release all muscles for perfect coördinate action in movement.

In the first paper, it will be remembered that the structure was divided into three principal units of weight, or bony "blocks," the pelvis, the thorax, and the skull. If the median line passes through the center of weight of all the units, there would be equal pressure at all points of the wall of each unit, and these three units of weight would hang at the point of least resistance, or in equilibrium. Therefore, all parts of the structure contacting with these balanced units of weight would be free from uneven pulls or strains. The conclusion reached was that if the three bony "blocks" and the shoulder girdle were not in equilibrium in relation to the central line of the structure, they must be maintained out of position by an increase of muscular effort.

THE INTERDEPENDENCE OF PARTS.

Continuing the above argument, a fixed position of any part of the three bony units would tend to hold that part of the spine with which it is in contact, in a stiff position. A state of fixation in any one part of the spine naturally induces the necessity for greater motion in some other portion of the spine, and we thus have an unequal strain upon the spinal column. For example, when you ask anyone to stand erect, he usually does certain definite things; raises his sternum and stiffens his ribs, thus maintaining the thoracic structure out of alignment at the expense of undue muscular effort.

The struggle in the chest wall, induced by the above mentioned conditions, imposes an inequality of pull upon the spine, which interferes with normal functioning and is a waste of energy. For instance, if the sternum were elevated beyond the position of equal pressure in the ribs around their entire area, the ribs would thereby be pulled forward, losing their flexibility at the point of contact with the dorsal spine, thus bringing the weight of the thoracic wall out of position, or alignment, in relation to the skull and pelvis. The result would obviously be a tightening of all muscles and ligaments of the vertebrae of the dorsal spine. This would tend to produce an increased lordosis of the lumbar spine; as any lack of freedom in one part of the spine requires compensatory movement in adjoining parts. With continued repetition this position tends to perpetuate itself, and finally becomes a habit. The muscles and ligaments adjust their structures to the constant strain and we lose our sense of normal balance through what we might term a "false consciousness." With this false consciousness, or self-consciousness, coördination, or the mechanical reflex action of the various parts in movement, is lost to a large extent.

If the chest is lifted, the entire structure is laboring under a mechanical disadvantage. For many years this has been one of our glaring mistakes in physical education.

If the thorax and the pelvis are in equilibrium, thus freeing the articulating surfaces of the ribs with the dorsal spine, the spinal muscles will be released for coördination, and the lumbar spine will have a tendency to maintain its normal curve. Fixation of the muscles of the dorsal spine, with increased lordosis of the lumbar spine, throws the weight forward and thus weakens the support of the fifth lumbar, allowing it to slip forward, and this, in turn, tends to increase the obliquity of the pelvis, as will be shown presently under "Mechanics of Hip-joint." By increased obliquity of the pelvis, the muscles connecting the head of the femur with the acetabulum, would have an inequality of pull and the weight of the torso is thereby brought out of alignment with its foundation, and its support at the head of the femur weakened. Any inequality of pull of the muscles of the lumbar spine, or of the muscles supporting the femur in the acetabulum, produces an uneven balance of the weight of the structure upon the head of the femur, with resulting strains and the consequent loss of the free action of the hip-joint. This will not only bring a strain upon the muscles of the pelvis and of the hip-joint, but will also produce a strain upon the spine, owing to the unequal pressure upon the vertebrae and the inevitable compensatory action of the fifth lumbar.

An unequal pull of the deep-lying muscles and ligaments around the head of the femur would make normal functioning at this point difficult, if not impossible. The superficial muscles are thus called upon to assume part of the responsibility of supporting the weight of the body. In a general way, the function of the deep-lying muscles might be regarded as that of maintaining a pull upon weight back toward center; and the function of the superficial muscles, that of pulling weight away from center, as in the voluntary movements of the limbs* This interplay of deep-lying and superficial muscles of the body equalizes inner and outer stress, thus maintaining equilibrium. The result is perfect coördination, and the weight of the body is carried with the least expenditure of effort.

Through coördination of the many groups of muscles of the body, there results a unity of force which secures freedom of action in all parts. The bony structure should be so balanced that every ligament and muscle receives the least possible strain, and every muscle of the body is ready for active coördination in the readjustment in the various units of weight, necessitated by movement. In a natural or perfectly balanced structure, every organ would be in a position for best functioning, and there would be a normal relation of all parts of the

* By the superfical muscles are meant all muscles involved in the voluntary movements of the extremities.

chanism. This balance of parts should be maintained in movement as well as when the structure is at ease. If the weight of the pelvis is balanced in proper relation to the weight of the thorax at their mean center, as has been explained, it will be seen that the articular surfaces of the sacrum and the fifth lumbar vertebra will be in normal contact. The contact of this articulation is normal when the weight of the vertebrae of the spine rests evenly upon the sacrum, and all spinal muscles are free for coördination, otherwise weight of the spine would be maintained at a disadvantage. The amount of weight to be adjusted is not important. The significant fact is that all structures, and parts of structures, must be balanced. Each integral part of a structure must rest evenly upon that part directly beneath it if freedom from strain, and coördination of parts is to be attained. With the articulation of the fifth lumbar and the sacrum normal, the lumbar spine will retain its natural curve and the deep-lying muscles of this region will have their proper alignment, or their normal perpendicularity. This will bring the weight of the torso upon the center of the head of the femur in its contact with the acetabulum.

Faulty adjustment of weight at one point always implies mechanical readjustment or necessary reaction of another point to compensate; and so we note that the interdependence of parts of the whole structure in its bony articulations and between its muscular groups is such as to produce great disadvantage to the structure if local freedom at any articulation is not maintained.

THE RELATION OF THE HEAD OF THE FEMUR TO THE ACETABULUM AND THE NORMAL MECHANICS OF THE HIP-JOINT.

If the entire weight of the body rests evenly upon the head of the femur the psoas and the iliacus muscles would have their normal alignment. These muscles give the femur muscular support at the front (See Plate IV.). With these muscles functioning normally, the weight of the leg, when in motion, is suspended from the center of the torso. The nearer weight is maintained in the center of a structure, the better. In obedience to this law, the leg has support from within the torso by the above deep muscles, while the superficial or voluntary muscles swing the weight of the leg in walking. For a mechanical example, let us suspend a fifty-pound weight on an iron chain from the ceiling and throw out from it a dozen ribbons to as many children,—you have formed a May-pole. Any child may pull on its ribbon in any direction and swing the weight, but the weight is still supported by the chain.

LIGAMENTOUS SUPPORT OF THE HIP-JOINT.

In the following illustrations we observe three aspects of the hip-joint and its ligamentous support. In Plate I we see the strength of the bony fibre in the head of the femur at the center of support and the apparent equality of pull of the deeper ligaments maintaining the femur in normal position.

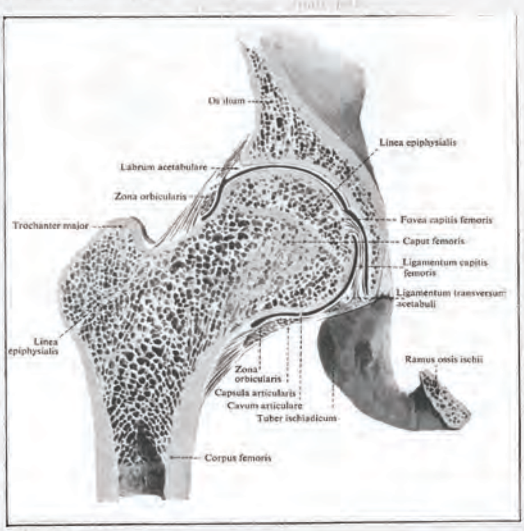

PLATE I.—All plates taken from Hand Atlas of Human Anatomy by Werner Spalteholz.

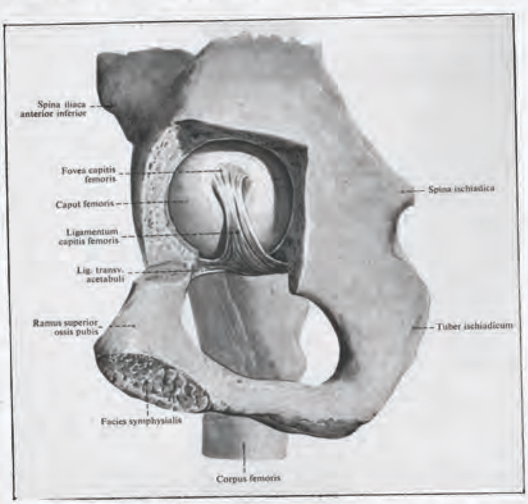

PLATE II.—The hip-joint is shown as it appears from within.

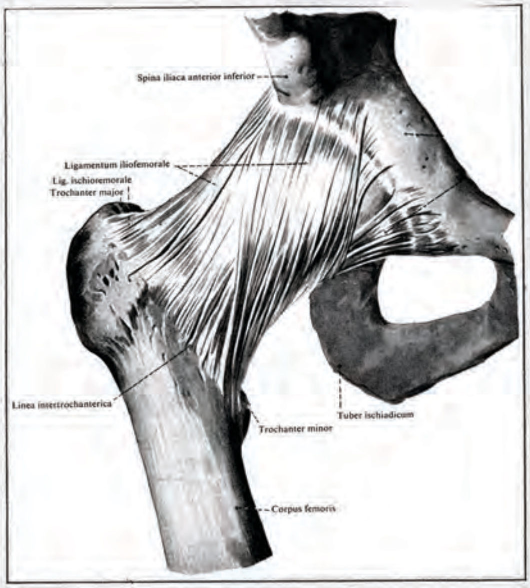

PLATE III shows the various layers of ligaments which, in their cross-fibered alignment, afford strength of support and, at the same time, a resiliency which affords freedom of movement in the joint in response to muscular pull.

If the weight of the three bony groups or units, the pelvis, the thorax, and the skull, were adjusted at the median line, an equalized stress at all parts of each group would result. The weight of the whole would then rest evenly upon the head of the femur, thus freeing its articulation with the acetabulum from unequal strain. With all muscles and ligaments of this articulation in equalized tone, and the body-weight balanced upon the femur, this joint would retain its normal functioning under all conditions, and the spine would remain free from any compensatory action at the fifth lumbar and the sacrum. To have this adjustment, we must have all articulations of the spine and of the pelvis free, and all connecting tissues in a normal state of elasticity. Especially must there be perfect freedom and equality of play of the muscles of the hip-joint. This joint tends, in a way, to act as a shock absorber to protect the spine and the torso from the weight of the body in its contact with the earth, and the consequent jar. Every time we step, our one hundred and fifty pounds weight has to be transferred through this articulation to the feet. The ligaments of this articulation, or joint, lose much of their power as shock absorbers if the muscles connecting the femur with the pelvis are unequal in their play. If one recalls the insertion and position of these various muscles, it will be seen that the area of origin inside the pelvic wall is far greater than the point of insertion in the head of the femur.

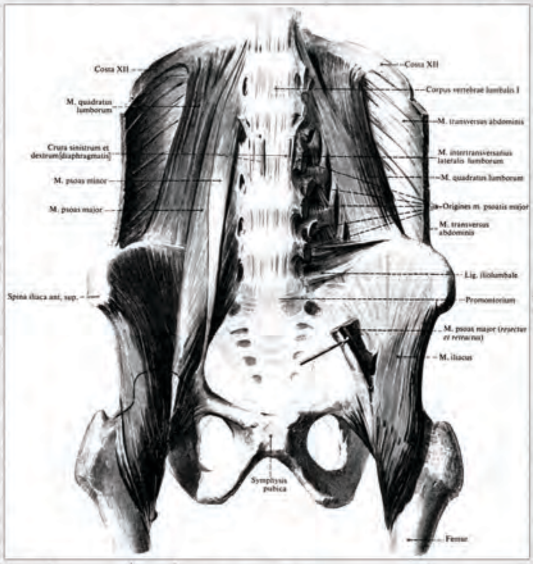

PLATE IV.

In Plate IV, the psoas and iliacus muscles are shown supporting the head of the femur at the front. The psoas, having its origin at the intervertebral discs and lateral surfaces from the twelfth thoracic to the fifth lumbar vertebra, and its insertion in the fascia iliaca, aids in maintaining the normal obliquity of the pelvis and in supporting the femur at the front.

The iliacus rising at the anterior surface of the ilium fascia iliaca, and spina iliaca, anterior, superior, and inferior forms a circular surface lining the ilium. It converges downward in front of the hip-joint, and is inserted in the lesser trochanter. Its origin being on the inside of the ilium and its insertion in the head of the femur indicates its function as that of giving the femur support at the anterior rim of the acetabulum .

The muscles at the back which aid in supporting the head of the femur in normal position are the piriformis and the obturators, as seen in Plate V. It will be recalled that the piriformis has its origin at the inner surface of the sacrum, and converging, its fibers run through the foramen ischia of the ischium, lateralward to the tip of the great trochanter. The obturator internus arises on the medial surface of the inner side of the ischium, and bending at right angle, passes to its insertion at the back of the great trochanter. The obturator externus is included in this group. The th e muscles give the femur support at the back and the psoas major and the iliacus give it support at the front, whereas the rectus abdominus, the psoas minor, and the quadratus lumborum aid in maintaining the normal obliquity of the pelvis. Added to these deep-lying muscles are the lower back muscles, the abdominal oblique and the transversus. The ligaments connecting the great trochanter and the head of the femur to the acetabulum would have equal stress if all of these muscles were properly performing their function and the weight of the torso would rest evenly upon this joint.

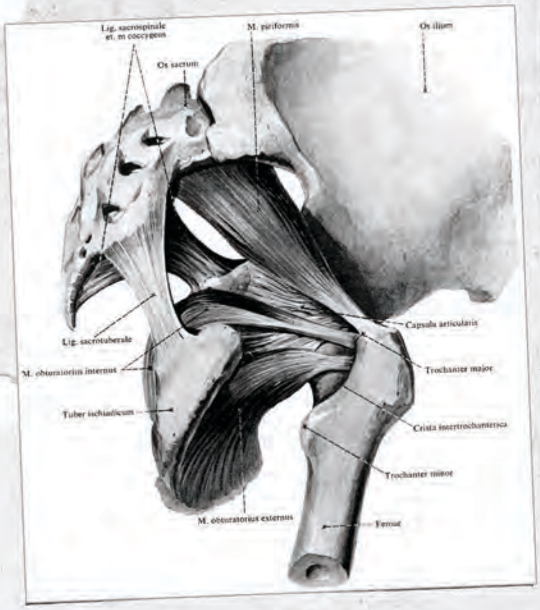

Plate V.

If we incline the body forward in preparation for a step with the weight of the pelvis and of the thorax in proper adjustment at the median line, the torso evenly balanced upon the head of the femur, the ligaments and muscles controlling the action of the hip-joint will be free, and the leg will swing forward supported by the equalized play of the deep-lying muscles mentioned above.

The circular area at the origin of these muscles in the pelvis, with each muscle converging to a tendinous point at its insertion in the femur, affords a resistance to all outward movements of the leg and receives the recoil of outward thrusts. This action may be likened to that of the wire spokes of a bicycle wheel. The pull upon the wire spokes must be absolutely equalized at the rim of the wheel. Otherwise it is obvious that the weight from above, and an irregularity of contact at any point of the rim of the wheel in traveling, would produce too great a strain or concussion upon the rim, and the structure would break at its point of least resistance. Such shocks of weight and concussion must be absorbed somewhere in the mechanism, and if the spokes are all of equal tension, the strain will be equally distributed: otherwise the strain would fall upon the main structure of the framework.

The function of the hip-joint may be likened in anatomical construction and physiological functioning to such a mechanism. Plate VI is a diagramatic drawing suggesting this point.

Plate VI.

If the iliacus muscle were shown in this plate, one would note the circular area of the origin of the hip muscles on the inside of the pelvis; and these muscles, the iliacus, psoas, obturator and piriformis in their diverging fibers, suggest the spokes of the bicycle wheel.

If equality of play of all the deep-lying muscles of this joint is not maintained, its freedom is lost and the spine must receive the recoil which should be absorbed in great part at this joint. Inner and outer stress must be equalized in a structure, if perfect equilibrium and full power of the structure is to be maintained. The evidence of this law of physics may be observed in annealing glass and steel. To obtain the greatest power of resistance to external forces, stresses originating within the structure must be equalized as far as possible to enable it to withstand greater stress from without. This principle is also shown in all mechanical action. Every outward impulse of a structure must be balanced by inner stress to absorb the recoil. If this were not true, there would be no power in the outward thrust, as there would be no resistance, and if there were no resistance, the body behind the thrust would go with it.

For example, the power expended in the leg which kicks a football across the field must be resisted by an equality of stress somewhere within the structure, and this area of resistance must equalize the stress of all muscles concerned in the action. If not absorbed in the legitimate joint at the head of the femur and the acetabulum, through the equalized support of all the deep-lying tissues of that articulation, and the equalized resistance of the fibers of these tissues at their origin, compensatory action and thereby strain, must be conveyed to the spine. This would weaken the muscular support around the fifth lumbar and the sacroiliac.

To repeat, if a boy kicks a football, the number of pounds pressure required for that kick must be sustained by resistance somewhere within the body. If the inner muscles of the pelvis are perfectly free and equalized in action and stress, the weight of the body will be maintained upon the head of the femur, and the same muscles which are aiding in the maintenance of this equilibrium of weight will receive the recoil and the shock of the forward impetus of the leg. Any lack of freedom or action in these muscles, and the shock of the leg movements will then be delivered to the spine by compensatory action at the fifth lumbar.

Briefly, the hip-joint is like a wire-spoke bicycle wheel; the head of the femur being the weight-carrying hub, and the obturators and the iliacus the radiating spokes, which maintain the equality of stress within the rim necessary for the equal distribution of resistance. Also, like the wheel, the inherent tension in the ligaments and the muscular fibres, holds the head of the femur in equalized suspension in the acetabulum, ready to transmit without slack or undue rebound, the anticipated stress received or imposed in action.

We recognize that the spine should always be protected from uneven or irregular stress or recoil from the activities of the extremities, or the reactions of the weight or concussions of the body. Lack of normal functioning in any legitimate joint conveys the irregular strain to the spine, and its unity of action and reaction is lost. Fix any point, and you bring a strain upon the whole unity of action, due to the interdependence of all integral parts of the structure. For a simple example of this, if one were to place the fingers on the cervicle vertebrae of a subject (who is standing in a relaxed position), and ask him to throw the hips back and thus increase the curve of the lumbar spine, an increased curve in the cervical spine will also be noted, provided the subject maintains freedom of the superficial muscles of the neck so that the mechanical reaction in the spine may be felt in the vertebrae.

As a summary of the foregoing principles, it may be said that when an inert mass is maintained with equal stress at all points in all directions, it is in equilibrium. Our weight is maintained in the bones of the structure, therefore, if there be equal stress upon all points in all directions, they would be maintained in equilibrium with the least expenditure of muscular effort. If this mechanical fact is one of the governing factors of the human structure, then the bony articulations would be found free at all points of their contacting surfaces when weight of the bony structure is so balanced as to produce equal stress at all points in all directions. We must find such a position for the maintenance of the weight of the structure as will secure the greatest protection to the whole organism, especially to the spine, from the strain and jar o fthe varying adjustments of the weight when in motion. One of the principal joints for this protection is the articulation of the head of the femur with the acetabulum. With proper resiliency at this joint and equalized action of all its muscles and ligaments, we have the necessary mechanical adjustment for absorbing the recoil from the varying outward thrusts of the leg and the consequent shifting of weight.

In conclusion, structures aiding to maintain the obliquity of the pelvis and the free articulation of the hip-joint are the following muscles: psoas major and minor, piriformis, obturators, and the ligaments of the sacro-iliac and those connecting the head of the femur with the acetabulum and the fascia of the spinal muscles in the lower part of the back.

We also have the muscles of the abdominal wall, particularly the rectus abdominis. Upon these deep-lying tissues largely depends the balance of the weight of the torso upon the head of the femur, and the determination of the obliquity of the pelvis. Therefore freedom of all these tissues is absolutely necessary to insure perfect balance of the weight of these parts.

Book Reviews.

Hygiene of Communicable Diseases. By Francis M. Munson, M. D. Paul B. Hoeber. New York. 1920.

An excellent manual of information, available at the present time concerning the epidemiology and the management on sea and land of communicable diseases, is contained in this volume, "Hygiene of Communicable Diseases." The subjects of epidemiology, prophylaxis, and sanitation are presented in concise, readily accessible form, in such a way as to be of practical value to the physician, sanitarian, sanitary ngineer, missionary or medical officer. The carefully headed sections, sub-sections, and paragraphs, make this book an unusually helpful one for reference in emergencies A chapter devoted to a new subject, sanitary measures following great disasters, is of considerable interest and practical value. Naval sanitation, railway sanitation, municipal and rural sanitation, and sanitation in schools, prisons, and industries are among the topics to which detailed consideration is given. The second part of the book describes diseases spread by oral and nasal discharges, the fecal-borne diseases, the venereal diseases, insect-borne diseases, diseases spread by infected animals, and wound infections. This book is an excellent treatise of an important subject.

Publications from the Dermatological Research Laboratories of Philadelphia. Vol. II. 1920. Collected Reprints.

The Dermatological Research Laboratories were instituted in 1912 by a citizen of Philadelphia and supported by him for four years. During this time, the work of research was mainly on the lines of psoriasis, and resulted in the publication of a number of essays on this subject. Later, it was found that the laboratory facilities authorized a broader research and the production and study of new chemical compounds designed to destroy the germs of various infectious diseases were undertaken. At first, the investigations dealt chiefly with mercury compounds; later, they began the elaboration of arsenic compounds. At about this time the supply of salvarsan threatened to be cut off on account of the war, and a successful attempt was made in the laboratories to reproduce this complicated chemical compound. Under the name of arsenobenzol, salvarsan was made and distributed to hospitals and physicians throughout the United States. The profits made from the sale of this drug have been and are being used to support the medical research laboratories, and this has resulted in the publication of over seventy contributions to science.

The present is Volume II of the Collected reprints of the laboratories' publications, and comprises thirty-two papers, published in a number of different periodicals. The director of the staff is Dr. J. Frank Schamberg, his assistants being Drs. John A. Kolmer and George W. Raijiss, and a majority of the papers are by these men, sometimes with the assistance of the auxiliary staff. Naturally, syphilis, and especially its modern methods of treatment and the study of the chemical compounds used therapeutically, are the subjects of a large number of the essays. Some studies of the etiology of influenza, of the pneumococcus, and of the diphtheria bacillus, are included. As would be expected from the names of the authors, these essays are all of high scientific value, and offer a notable contribution to the American literature on these important subjects.

MEDICAL REGISTRATION IN MASSACHUSETTS.

The results of the May examinations conducted by the Board of Registration are as follows:

Graduation from	Registered	Rejected
Massachusetts College of Osteopathy		3
Kentucky School of Medicine		1
Tufts Medical School		2
College of Physicians and Surgeons of Boston	1	2
Middlesex College of Medicine and Surgery	1	7
College of Physicians of University of Southern California		1
Woman's Medical College, Pa.	1	
Laval		1
University of Valdimir		1
University of Maryland		1
University of Lisbon	1	
College of Physicians and Surgeons of Baltimore		1
Baltimore Medical College		1
Fordham	1	
	5	21