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VISCERO-SOMATIC AND SOMATO-VISCERAL SPINAL REFLEXES.

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Results to be Attained.

In the study of the physiology of the sympathetic nervous system it was noted that a lack of clearness was especially evident concerning the locality in which the viscero-sensory impulses affect the viscero-motor nerves. It occurred to me that a study of viscero-somatic and somato-visceral spinal reflexes might assist in determining whether this co-ordination takes place chiefly in the sympathetic ganglia, or chiefly in the spinal cord. It is evident that viscero-somatic reflexes would be impossible if viscero-sensory nerves did not enter the cord, or if they did not form either direct or indirect physiological relations with the somato-motor neurons. On the other hand, somato-visceral reflexes would be impossible were not the somato-sensory axons related with the viscero-motor neurons.

Resume of Previous Investigations.

Since the work of Claude Bernard, in 1850, the vaso-motor nerves have been studied. For the most part these studies have been directed either to the study of vaso-motor phenomena or to the study of the effects of the stimulation of certain nerve trunks. The origin of these impulses from a chief center in the medulla and from subsidiary centers in the lateral horn of the spinal cord have been described by many observers.

Fletcher has shown that the vaso-constrictors for the cranial region arise chiefly as white rami communicantes from the second, third and fourth thoracic nerves. These terminate, for the most part, by forming synapses with the sympathetic neurons of the superior cervical ganglia.

Bradford and Dean, (Journal of Physiology, 1894,) found evidence of the existence of the vaso-constrictor fibers to the pulmonary arteries in the third, fourth and fifth thoracic nerves. These results have been both verified and disputed by more recent physiologists.

The stomach and intestine receive vaso-motor fibers through the splanchnic nerves arising from the fifth thoracic segment and downward. (Hallion, Francois-Franck.) According to these same observers, and also to Bradford, the kidneys and the liver receive vaso-motor fibers from the splanchnic nerves arising from the eleventh to the thirteenth thoracic segments, in the dog. Doyon has proved the greater splanchnics to be motor to the biliary ducts.

Langley, working also on the dog, traces the vaso-constrictors of the external genitals from the thirteenth thoracic to the fourth lumbar segments. The vaso-dilators for this region are mostly derived from the sacral nerves by way of the nervi erigentes. The internal genitals receive vaso-constrictor and vaso-dilator nerves from the upper lumbar nerves.

Bechterew and Mislawski trace motor nerves for the small intestine from the sixth dorsal to the first lumbar segments of the cord, by way of the splanchnic nerves and the semi-lunar ganglia.

According to Howell, Langley and Anderson, Bayless and Starling, and others, the large intestine receives motor nerves—mostly inhibitor—from the second to the fifth lumbar segments, in the cat. The nervus erigens supplies the rectum and descending colon with motor nerves.

The experiments of Goltz upon dogs and the work of succeeding physiologists indicates that the center for defecation (Budge's anspinal center) is found within the lumbar segments of the cord. The centers for erection and ejaculation in the male and of parturition in the female are also placed in the lumbar cord. Budge's cilio-spinal center lies near the second and third thoracic segments.

Morat and Dufourt caused an increased formation of sugar from glycogen by stimulating the great splanchnic nerve.

Argutinsky (1899) finds a marked appearance of segmentation in the lateral horns of a new-born babe, but doubts the existence of a true segmentation. Dana, Mackenzie and Head, writing from the clinical standpoint, have proved the intimate physiological relation between the nuclei of insertion of the viscero-sensory and the somato-sensory nerves.

Barker described the collaterals from the axons of the sensory cells as entering into relationship with both the antero-median and the lateral groups of cells of the ventral horn of the cord. The latter is the lateral horn of other authors.

Bartenstein's experience at Breslau, (Jahrbuch F. Kinderheilkunde, Berlin,) confirms Head's assertion in regard to the increased sensitiveness of certain zones of the skin in cases of affections of the internal organs. He believes it may prove possible to influence the internal affection by revulsion applied to these zones.

The views of Cornelius, of Meningen, (Klinish-therap. Wochft., Nos. 35-41, 1903) are of interest in this connection. He finds "painful spots" (somato-sensory) associated with those gastro-intestinal disturbances which are considered as purely nervous. Irritation of these points precipitates an acute attack, while gentle massage, which relieves the pain, inhibits or aborts the viscero-motor storm.

Essential Structures.

The gross anatomy of the nervous structures concerned 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 axons give off collaterals which penetrate the gray matter and form synapses with the cells of the anterior, posterior and lateral horns, and with the cells of Clarke's column. According to Barker, probably every entering axon sends collaterals to every region of the gray matter of the same and probably adjacent spinal segments. The ordinary somatic segmental reflex actions are governed by impulses carried over somato-sensory nerves either directly or by means of interpolated neurons to the motor cells of the anterior horn. 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. All these fibers terminate by forming synapses with sympathetic neurons. According to Howell, there is probably only one relay between the lateral horn cells and the destination of the nerve impulse. The probable pathway of the impulses concerned in visceral reflexes include a viscero-sensory neuron, a neuron whose cell-body lies in the lateral horn, and one sympathetic neuron. One or more of the associational neurons within the cord may also be included in the reflex arc. If these structural relations are true, and there is much evidence in their favor, somato-visceral and viscero-somatic reflexes are an anatomical possibility.

Conditions of Experiments.

The series of experiments here cited were performed upon animals and human beings. The subjects employed in the experiments quoted were young and healthy. The principles noted were found to hold true, however, under many abnormal conditions both among diseased animals and diseased people, except where the pathological condition involved a gross structural defect. Among these abnormal subjects the reflexes were variously modified, as was to be expected.

The animals used were not permitted to suffer pain, nor to recover consciousness after mutilation. Ether, chloroform, cocaine, morphine and ether-alcohol were employed to secure partial or complete anesthesia. Cats, dogs, guinea-pigs, frogs, toads and white rats were used in the series. Only the experiments upon cats, dogs and people are here quoted. Unless otherwise stated, every reaction was verified upon at least five, and usually ten or twelve individuals.

The tracings of the respiratory curves were made with Marey's tambour, with an extra tambour pan two and a half inches in diameter placed over the apex beat of the heart. The pulse tracings were taken with Dudgeon's sphygmograph. The sphygmomanometer used was a modification of the Riva-Rocci apparatus. A Du Bois-Raymond coil was used for the electrical stimulation and the minimal stimulus usually employed.

The human subjects were kept in ignorance of the nature of the expected reaction, and the psychical factor was eliminated as far as possible.

Viscero-Somatic Reflexes upon Animals.

The experiments upon the thoracic viscera will be first mentioned. The thorax was opened under ether or chloroform narcosis. The electrodes were applied to the visceral pleura of the upper part of the upper lobe of the lung. The first inter-costals of the same side were strongly contracted. Upon increasing the current, the other inter-costals of the same side, and those of the other side were also contracted. The electrodes were placed upon different areas of the visceral pleura, and the inter-costals normally covering the area stimulated were contracted. The lobes of the lung were displaced (but not cut) and the segmental, or pseudo-segmental, reactions remained constant. Contractions of the diaphragm, the quadratus lumborum, and occasionaly the abdominal muscles were initiated by the stimulation of the lower lobes of the lung. After the removal of the pleura the reactions were somewhat more widely diffused, but were otherwise unchanged. In the dog, the inferior lobe on the right side lies next the diaphragm but does not touch the lateral walls of the thorax. The stimulation of this lobe initiated the contraction of the diaphragm but not of the inter-costals. After the section of both vagi above the superior cervical ganglion, the reactions were not perceptibly affected, but after section of both vagi below the superior cervical ganglion the reactions were scarcely to be noted. After section of the vagi below the stellate ganglion, and in some animals even higher, the reactions were not to be secured at all under the conditions of our experiments. In the dog the cervical gangliated cord is bound up in the sheath of the vagus. The same relation was observed in some of the cats.

The stimulation of the parietal pericardium gave slight inter-costal contractions, occasionally apparently segmental. The contraction of the spinal muscles near the third, fourth and fifth thoracic vertebrae was fairly constant. The stimulation of the visceral pericardium and of the heart muscle initiated the contraction of the left second to sixth inter-costals, and of the spinal muscles near the second to the fifth thoracic vertebrae. The most marked and constant muscular contraction was found near the fourth thoracic spine.

Stimulation of the larynx, pharynx, trachea and thyroid gland initiated the contraction of the muscles near the second and third thoracic vertebrae.

For the experiments upon the abdominal viscera, the abdominal wall was cut, and the viscera exposed to view with as little manipulation as possible. The stimulation of the inner wall, the muscular coat and the peritoneal covering of the cardiac end of the stomach or of the fundus was followed by the contraction of the spinal muscles near the sixth to the ninth thoracic vertebrae. The same stimulation applied near the pylorus gave rise to the contraction of spinal muscles one or two segments lower, in a given animal, than those last mentioned. The stimulation of the duodenum, pancreas, and gall-bladder caused the contraction of the spinal muscles near the tenth and eleventh thoracic vertebrae, (cat or dog.) The stimulation of the rectum, bladder, cervix uteri, and prostate initiated contractions near the lumbo-sacral articulation. Stimulation of the caecum and appendix initiated the contraction of muscles near the fourteenth thoracic and first lumbar vertebrae. Portions of the intestine between the duodenum and rectum gave rise to muscular contractions fairly proportionately divided between the tenth thoracic vertebrae and the lumbo-sacral articulation. The stimulation of the ovaries and testes contracted the muscles near the tenth thoracic vertebrae, the kidneys the twelfth and thirteenth and the supra-renals the thirteenth.

None of these reactions were apparent after the destruction of the sympathetic ganglia of the fifth to the fourteenth thoracic nerves. The destruction of these ganglia implies the destruction of the splanchnic nerves. The reactions just described were not apparently affected by section of the pneumogastrics.

The stimulation of the Fallopian tubes, or of the double uterus, pregnant or virgin, did not initiate any apparent contraction of skeletal muscles until the current was so greatly increased as to give rise to the suspicion that the observed results were directly produced by the electricity.

The abdominal muscles normally in relation with the viscera stimulated were contracted in every instance in which the nerves concerned were intact. The skeletal muscles innervated by the branches of the lumbar plexus were frequently but not invariably stimulated.

Somato-Visceral Reflexes upon Animals.

The relations determined in section V were held indicative of certain possibilities in testing the visceral effects following the stimulation of somato-sensory nerves. 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 inconstant and not conspicuous. Reasoning that since the skin and superficial tissues are normally subject to great variations in stimulation the liminal value of the neurons concerned in their sensory innervation must be comparatively great, the attempt to employ the sensory nerves of the skin was abandoned. Mechanical stimulation of the sensory nerves in the muscles, tendons and joint tissues by pinchings and by quick, forceful movements were more successful. The joints were never dislocated by the movements given.

In the following series these mechanical forms of stimulation were employed unless otherwise stated.

In all the somato-visceral reflexes the latent period was longer than in the corresponding experiment of the preceding series, and was very variable, both in different individuals and the same individual during the experimetal manipulations.

The experiments of this series were as follows:

The thorax remaining intact, and the abdomen opened, the color of the lungs was noted through the central tendon of the diaphragm. In dogs, this tendon is very large and thin. The experiment is not easily duplicated in the cat, in whom the tendon is small. Stimulation of the deeper spinal muscles near the fourth and fifth thoracic vertebrae lightened the color of the lungs perceptibly. After a few minutes rest they reddened again, and again after the same stimulation they became lighter. There seemed to be no limit to the repetition of this experiment except the life of the anesthetized animal.

The thorax was opened and the lungs collapsed. The same results were secured. The cardiac nerves were divided in order to eliminate cardiac effects. The same results were again secured. The vagi were divided above the superior cervical ganglion. The results were not perceptibly changed. After section of the vagi below the superior cervical ganglion the reaction noted above was either very faint or entirely absent. No effect could be secured after the extirpation of the stellate ganglion, though the vagi remained intact.

Any segmental (or pseudo-segmental) reaction corresponding to that mentioned in section V was too slight to be perceived. The lungs were unequally affected, the change being first noted on the side stimulated, and then on the other.

The somato-visceral reflexes affecting the heart were most satisfactorily studied upon human beings, and will be described in a subsequent section. The results obtained with animals were in harmony with these.

The stimulation of the tissues near the fifth to the eighth thoracic vertebrae was followed by muscular and secretory activity in the stomach, and stimulation near the eighth to the twelfth thoracic vertebrae was followed by activity of the intestines. (These same movements were inhibited by the direct stimulation of the splanchnic nerves. No explanation is offered for this paradox.) The blood vessels were constricted and the blood pressure raised. By the use of a reading glass, the contraction of the smaller arteries was evident. The intestinal temperature was perceptibly raised, though the intestines were exposed to the air. After a few minutes of rest, the color returned to that observed upon opening the abdomen, and the experiment could be repeated.

After section of the vagi, the results above noted were intensified. In these cases, the direct stimulation of the splanchnics initiated reversed peristalsis. Bile was quietly ejected from the mouth in some instances, and was found in the stomach in all in whom the direct stimulation of the splanchnics followed the section of the vagi. After section of the spanchnics the stimulation of the spinal muscles produced no perceptible effects upon any of the abdominal viscera.

The appearance of a roughly segmental reaction, noted in Section V was not noted in connection with visceral action. An appearance of the segmental relation was evident in connection with the vaso-motor changes.

Stimulation near the tenth thoracic spine was followed by a partial evacuation of the gall-bladder.

Stimulation near the thirteenth thoracic spine was followed by dilatation of the supra-renal vessels, and a little later, by an increase in the blood-pressure and a lightening of the color of the abdominal and thoracic viscera, but similar changes in the vessels of the brain and skeletal muscles were doubtful.

In a single instance, stimulation was given near the second lumbar spine of a pregnant cat. After two or three minutes uterine contractions began, but were not accompanied by any relaxation of the cervix uteri. The uterine contractions were rhythmical and of increasing strength. They continued for about twenty minutes, at which time the uterus was opened and emptied.

Stimulation of the tissues from the third lumbar spine to the lumbo-sacral articulation were followed by imperfect movements of urination, defecation, and erection.

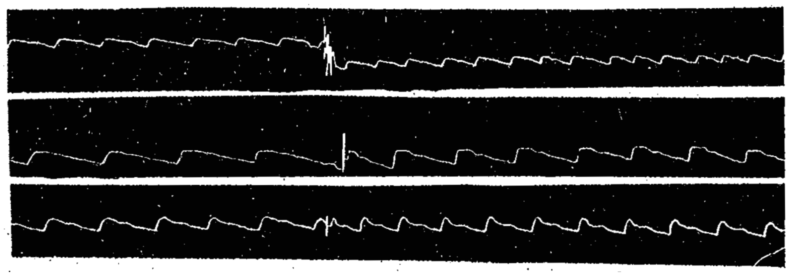
Another point noticed in this connection may be of interest. It was noticed that firm pressure, such as inhibits conscious sensory impulses, inhibited also the functions which were stimulated by mechanical irritation.

Steady pressure at the sides of the fourth to the sixth thoracic spines was followed by the dilatation of the pulmonary vessels. Rest permitted them to return to their normal condition. Steady pressure at the sides of the fourth thoracic spine was followed by a variable slowing of the heart rate. Steady pressure near the eighth to the thirteenth thoracic spines lessened peristalsis and decreased the tone of the visceral walls and their vessels. The vessels became distended with blood under low pressure and of venous appearance. The intestines became distended with gas.

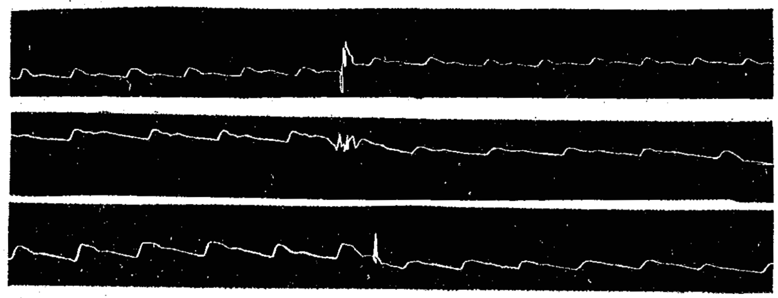
This accumulation of gas was accomplished with such celerity that the possibility of its formation from fermentation was excluded. Since intestinal puncture before the experiment was never followed by any perceptible escape of gas, it is not probable that any great amount of gas was present before the experiment. Subsequent stimulation of the area previously subjected to the steady pressure increased peristalsis. The vessels were again contracted, the blood-pressure was raised, and the blood became more arterial in appearance. The intestinal distention disappeared, and, after several minutes, peristalsis was again seen. Puncture of the intestinal wall at this time was not followed by any perceptible escape of gas. These experiments were repeated after the ligature of various parts of the intestinal canal, and the same effects were produced. It was therefore inferred that the gas was derived from the blood while it was flowing slowly under low pressure, and that it was re-absorbed when the blood-stream was quickened and the blood-pressure raised.

Experiments upon Human Subjects.

The sphygmograms illustrating the pulse changes initiated by the stimulation of somato-sensory nerves are submitted with this section. The sphygmograph was not removed from the wrist during the experiment. The stimulation employed was that mentioned in Section VI, namely, urgent shaking movements of the tissues near the spinal column. The endeavor was made to bring about such vertebral movement as to affect the nerves ending in the articular surfaces, as well as those of the muscles, etc. The break in the tracings indicate the time of the stimulation, during which the sphygmograph was stopped. The stimulation lasted for about two minutes, usually, though there seems to be considerable difference in the reaction time of different individuals.



Sphygmograms illustrating effects of mechanical stimulation near fourth thoracic spine.



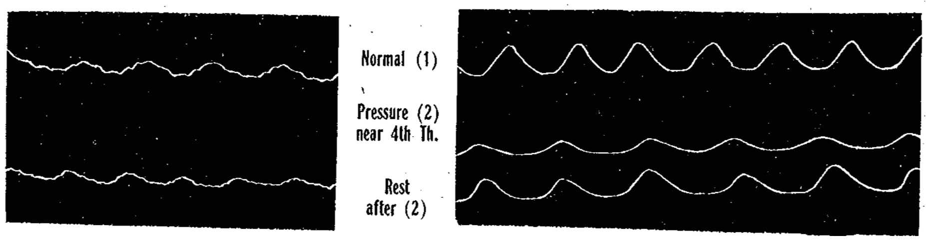
Sphygmograms illustrating the effects of steady pressure near fourth thoracic spine.

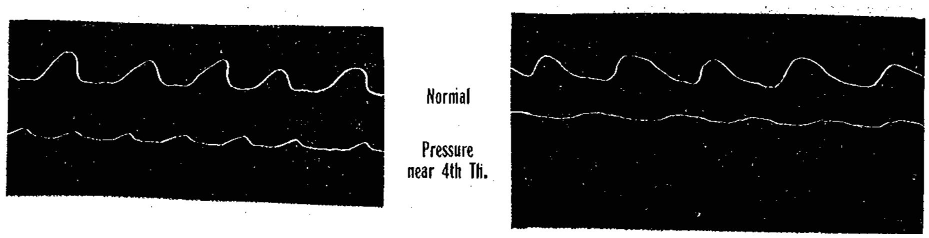
The effects of variations in somato-sensory impulses upon general blood pressure were usually decisive, though in a few individuals, especially those of strong masculature, the effects were less apparent.

The experiments were performed upon thirty-seven individuals. The subject was placed on a comfortable table and the blood-pressure taken until no further change occurred. The last reading was given as the normal, resting blood-pressure. The stimulation was the same as that already described. When steady pressure was used it was continued until no longer heeded in consciousness,—usually for two or three minutes. After each experiment the subject was discharged for several hours before being employed for subsequent tests. The results noted are tabulated below. Averages only are given.

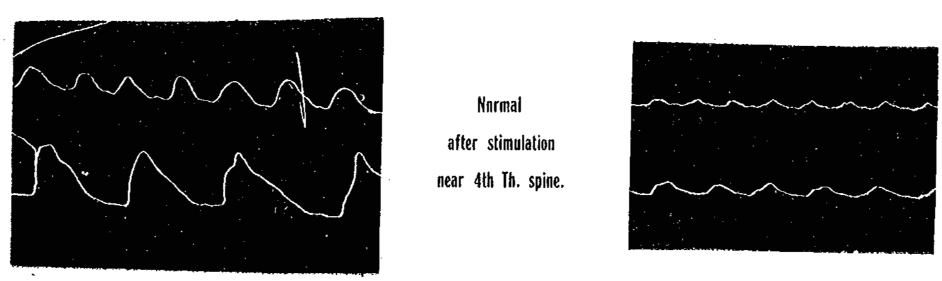
	Pulse.	Blood-Pressure.
Normal	73	125 m. m. of mercury
Stimulation near 4th thoracic spine	82	130 m. m.
Steady pressure near 4th thoracic spine	65	119 m. m.
Stimulation near 8-10 thoracic spines	75 (very variable)	138 m. m.
Steady pressure near 8-10 thoracic spines	70 (very variable)	110 m. m.

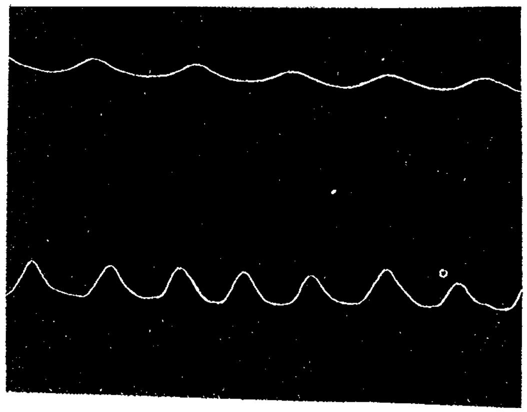
The following series of respiratory curves illustrates the effects produced by steady pressure upon the tissues near the fourth thoracic spine.





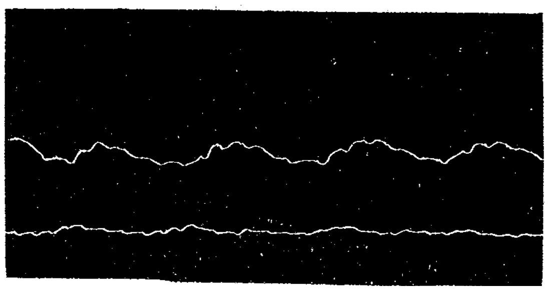
The stimulating manipulations referred to in connection with the pulse rate produced also changes in the respiratory curves. These effects are apparently due to vascular changes, as was the case in Section VI.





Normal

Stimulation near 4th thoracic spine



Normal

Steady pressure near 4th thoracic spine.

Inferences and Conclusions.

A very important, if not the only, pathway of viscero-sensory impulses enters the spinal cord through its posterior roots.

Somato-visceral reflexes are much less circumscribed and direct than are viscero-somatic reflexes.

Since abnormal conditions of the viscera follow such pressure upon somato-sensory nerves as is sufficient to lessen conscious sensation, and since section of somato-sensory nerve is followed by abnormal conditions of the viscera, it is inferred that normal visceral activity depends in part upon the stimulation derived from the somato-sensory nerves.

The possibility of recognition of abnormal viscero-somatic reflexes as an aid in diagnosis is inferred

References.

The following papers and books have been consulted in the preparation of this paper:

BARDEEN. The Growth and Histogenesis of the Cerebro-Spinal Nerves in Mammals. AMERICAN JOURNAL OF ANATOMY, vol. II, No. 2.

BARKER. The Nervous System. 1899.

BRUBAKER. Text-Book of Physiology. 1905.

CANNON. The Motor Activities of the Stomach and Small Intestine After Splanchnic and Vagus Section. AMERICAN JOURNAL OF PHYSIOLOGY, vol. XVII, No. 4.

CARLSON. The Rhythm Produced in the Resting Heart of Molluscs by the Stimulation of the Cardio-Accelerator Nerves. Journal of Physiology, vol. XII, No. 1.

IBID. The Function of the Cardiac Nerves in Molluscs. Journal of Physiology, vol. XIV, No. 1.

DANA. A Clinical Study of Neuralgias, and of the Origin of Reflex or Transferred Pains.

N. Y. MEDICAL JOURNAL, 1887.

DONALDSON. Central Nervous System, American Text-Book of Physiology, 1900.

GORDINIER. Anatomy of the Central Nervous System, 1899.

HALLIBURTON. Bio-chemistry of Muscle and Nerve, 1904.

HEAD. On Disturbances of Sensation with Especial Reference to the Pain of Visceral Disease. Brain, London, vols. XVI, XIX.

HOWELL. Text Book of Physiology, 1905.

JOHNSTON. Nervous System of Vertebrates, 1906.

LANDOIS. Text-Book of Physiology, 1905.

LOEB. Physiology of the Brain, 1900.

MACKENZIE. A Contribution to the Study of Sensory Symptoms Associated with Visceral Disease. Medical Chronicles, Manchester, 1892.

MORAT. Physiology of the Nervous System, 1906.

ONUF. Reference Hand-Book of Medical Sciences, 1903.

OTT. Text-Book of Physiology, 1904.

RAYMOND Human Physiology, 1905.

ROTH. The Relation Between the Occurrence of White Rami Fibers and the Spinal Accessory Nerve Journal of Comparative Psychology and Neurology, vol. XV, No. 6.

SABIN. Atlas of the Medulla and Mid-Brain, 1901.

SHINKISKI HATAI. A Note on the Significance of the Form and Contents of the Nucleus in the Spinal Ganglion Cells of the Foetal Rat. Journal of Comparative Psychology and Neurology, vol. XIV, No. 1.

WEEKS. Pathology of the Cervical Sympathetic.

THE JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION, vol. XLII, No. 5.

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Editor's note

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Gilbert E. D'Alonzo, DO