spinal cord. Dastre and Morat confirmed Budge's conclusions. Salkowski and Knoll denied the existence of a cilio-spinal centre, and placed the origin of the pupil-dilating fibres higher, Salkowski in the oblongata, Knoll in the anterior corpora bigemina.

On the other hand, clinical experience tended to confirm the existence of a cilio-spinal centre, since oculo-pupillary symptoms were found to accompany transverse lesions of the spinal cord in the lower regions of the cervical and the upper regions of the dorsal portion of the cord (Kraus). This evidence was not conclusive, however, since in a case of transverse lesion of the spinal cord the fibres would also be severed in their course through the white substance, even if they originated from the oblongata or corpora quadrigemina. We might say that although the evidence is preponderatingly in favor of the existence of a cilio-spinal centre, yet the question has not been definitely settled.

Coleman Balogh and François Franck showed, however, that not all pupil-dilating fibres contained in the first branch of the trigeminal nerve are derived from the cervical sympathetic, but that part of them reach the Gasserian ganglion by way of the roots of the trigeminal nerve.

The observations of Dr. J. Collins and the writer corroborate the contention that not all pupil-dilating fibres are contained within the cervical sympathetic nerve, since the narrowing of the pupil following removal of the cervical sympathetic (*i.e.*, of the stellate ganglion) in cats disappeared almost entirely in the course of months, and since, furthermore, in one case in which *one* stellate ganglion was removed first and the other one three months afterward, both pupils were still found to dilate in darkness.

Concerning the further course of the pupil-dilating fibres of the cervical sympathetic, only so much is known that they all finally join the Gasserian ganglion and leave the latter with the first branch of the trigeminal nerve (Coleman Balogh, quoted by Jegorow and Dogiel). They then pass through the long ciliary nerves to the pupil without forming connections with the ciliary ganglion (Jegorow and Dogiel, Nawrocki and Przybylski).

The question whether the cervical sympathetic contains also pupil-contracting fibres has, to our knowledge, been considered only by one investigator, viz., by Dogiel, who answered it affirmatively. The experiments of Dr. J. Collins and the writer tend to confirm his view, although not in an altogether unobjectionable manner. Dogiel's researches are quoted in detail in our report.

In addition to contraction of the pupil, section of the cervical sympathetic nerve causes a sinking in of the eyeball into the orbit, slight ptosis of the upper lid, and paralysis of the nictitating membrane. Heese finds that excitation of the sympathetic nerve causes protrusion of the eyeball in cats and dogs, while in rabbits it produces very marked sinking in of the eyeball. This discrepancy he explains by the fact that the sympathetic nerve displays its effect upon the eyeball in two ways: first, by the contraction of Müller's muscle; second, by vaso-motor influence. The former causes protrusion, the latter a sinking in of the eyeball. In cats the effect upon Müller's muscle predominates, therefore the protrusion; in rabbits the reverse is true.

According to Langley, the nerve fibres causing retraction of the nictitating membrane (third lid) and opening of the eyelid have in the cat a more extended origin than the dilator fibres for the pupil. They arise from the first four thoracic nerves, and sometimes from the fifth also. In nearly every case the second thoracic is most effective, the first more than the third; the fourth has slight effect, the fifth at best causes but a trifling movement.

That the cervical sympathetic has an influence upon the shape of the cornea is claimed by Claude Bernard, Brown-Séquard, and Hermann, who find that section of the cervical sympathetic causes flattening of the cornea. Their statements have been contradicted by Heese. Heese declares that the conclusions of Morat and Doyon, who contend that the sympathetic nerve influences the shape of the lens by displaying an effect antagonistic to that of the third nerve upon accommodation, are likewise erroneous. Jaboulay found amelioration of vision in two patients after severing of the cervical sympathetic nerve between the superior and middle cervical ganglia. He attributed this amelioration, however, not to any effect on accommodation, which latter he found quite unaltered, but to the narrowing of the pupil, which influenced myopia and astigmatism favorably in the manner of a stenopaic slit.

The trophic disturbances observed in the eye after removal of the stellate ganglion will be discussed in the next section.

The hypotension of the eyeball following removal of the superior cervical ganglion disappears entirely in the course of time, at least in non-glaucomatous cases (Jonnesco, Lagrange, H. Pachon).

VI. TROPHIC AND TONIC FUNCTIONS.—(*a*) *Trophic Functions.* Regarding the supposed trophic action of the sympathetic on the salivary glands, liver, and pancreas, the reader is referred to the paragraphs of this article which treat of these organs (pages 583 and 584).

Of other trophic effects, I mention, first, the retraction of the face and loss of hair as it was observed after lesions of the cervical sympathetic in man.

Moebius contends that the true form of facial hemiatrophy, characterized by discoloration and wasting of the skin, discoloration and disappearance of the hairs, wasting of the bones and cartilages, differs entirely from the slight flattening of the cheek observed with disease of the cervical sympathetic nerve. On the other hand, Angelucci has seen very marked trophic disturbances follow extirpation of the stellate ganglion. He found that in new-born dogs and in adult cats defect of one stellate ganglion gave rise (on the side of the operation) to alopecia of the face, dystrophy of the cranial bones, and deficient development of the teeth. In adult rabbits and monkeys these conditions were not usually met with.

Dr. Collins and the writer observed in young cats, in which one stellate ganglion or one thoracic sympathetic nerve had been extirpated, the appearance of red, hairless spots, which later became scaly, psoriasis-like, and then turned pale, smooth, till finally they healed up entirely, becoming covered with a new growth of hair. The distribution of these patches seemed quite irregular and arbitrary in case of resection of the thoracic sympathetic nerve, although in case of removal of the stellate ganglion they were confined to the head, affecting, however, both sides of the latter.

Max Joseph (*Virchow's Archiv*, vol. 107, p. 119) operated on the second cervical nerve in young cats and extirpated a continuous portion, including a piece of both roots, the entire spinal ganglion, and a piece of the peripheral nerve. This operation evidently implies tearing off the ramus communicans of the nerve, and it is interesting to note that he also observed, on the faces of the animals, hairless spots such as we found. Of no less interest is the fact that when he cut both roots of the second cervical nerve without injuring the spinal ganglion or any part of the nerve trunk peripheral to the ganglion, the hairless spots did not appear. From this the inference seems justified that the trophic influence of the sympathetic efferent fibres of the ramus communicans is sufficient to prevent the loss of hair, since in the latter experiment the cerebro-spinal motor fibres of the ramus communicans were cut in their course through the anterior (and posterior?) roots, while the sympathetic efferent fibres were left untouched. Fig. 4576 makes these conditions clear.

The almost instantaneous changes in the biceps femoris and psoas muscles noted by Gaule in rabbits after lesion of the stellate ganglion, which change she attributes to this lesion, are interpreted differently by Salvioli and Hering and need not therefore to be dwelt upon.

Angelucci has seen, in addition to the trophic changes referred to, interesting alterations in the eye follow extirpation of the stellate ganglion in new-born dogs—such alterations as lesser development of the circumference of

the cornea and sclera, the eyeball showing a lessening of about 1 mm. in its diameters. Both in new-born dogs and in adult cats, a long time after the extirpation of the stellate ganglion, distinct dystrophies characterized by simple atrophy and sclerosis occur, especially of the texture of the iris and of the choroidea. In the iris of new-born dogs the sclerosis of the tissue formed large plaques. The fundamental structure of the retina, however, was never found altered. Angelucci attributes the dystrophies reported, to changes in the blood-vessel walls, to which Vulpian and Giovanni had already called attention.

Floresco found that in rabbits section or resection of the cervical sympathetic nerves gave rise to an abundant production of fat tissue and to the hypertrophic development of the thyroid glands, the suprarenal bodies, the respiratory and digestive apparatuses, the heart, and the genital organs; while, on the contrary, the skin, the nervous and muscular systems, and probably also the osseous system became retarded in their development.

From all the facts mentioned, the important relation which the sympathetic nervous system bears to the trophic functions of the organism becomes highly evident.

(*b*) *Tonic Functions.*—It has been shown that many nerves of the sympathetic system are under the tonic influence of spinal or cerebral centres. Section of the cervical sympathetic nerve is followed by dilatation of the blood-vessels of the head; section of the abdominal sympathetic by dilatation of the blood-vessels of the hind paws; section of both splanchnics by the same phenomenon in the stomach and intestine. Severance of the nerves connecting the submaxillary ganglion with its encephalic centre gave rise to an unceasing continuous secretion of the submaxillary glands, proving the regulatory influence of the cerebro-spinal system upon the submaxillary ganglion (Claude Bernard). We recall further the experiments of Spallita and Consiglio, which showed that the tonus of the whole vascular system is kept up and regulated by means of the vaso-sensitive nerves.

Regarding the tonic influence of ganglia of the sympathetic itself, the views still differ. Tuwim claimed tonic effects of the stellate ganglion upon the pupil-dilating fibres, but such effects were denied by Schipiloff. We know, however, that the heart removed from the body still continues to beat, and that the bladder deprived of the motor nerves leading to it continues to perform its functions. It is quite questionable if the functions of maintaining tonus are different materially from the functions discussed under the heading of Vascular Functions (pages 584 and 585).

VII. REFLEX ACTION OF THE SYMPATHETIC SYSTEM.—We have already mentioned some facts that point to a considerable functional independence of the sympathetic system apart from the spinal and cerebral centres. We remind the reader of the two facts regarding the independence of the bladder and of the heart functions mentioned at the end of the preceding section, and of the observations of Contejean, according to which the secretion of gastric juice continues after the stomach has been deprived of all its nerve connections.

This independence of the sympathetic system from the cerebro-spinal system is further demonstrated by the reflex action of sympathetic ganglia, which seems a fairly well established fact. Sokownin, Nussbaum, Nawrocki and Skabitschewski, and Langley and Anderson produced evidence that made such reflex action very probable for the inferior mesenteric ganglion.

Claude Bernard apparently established the fact of the reflex action for the submaxillary ganglion. François Franck claimed it for the ophthalmic (ciliary) and for the superior thoracic ganglion. The details cannot be discussed here.

VIII. THE FUNCTIONAL INTERRELATION OF THE SYMPATHETIC AND CEREBRO-SPINAL SYSTEMS.—While, as has been shown in previous paragraphs, the sympathetic may to quite a degree functionate independently of the cerebral and spinal centres, its dependence upon the cerebro-spinal system is clearly shown by certain facts.

In this connection I recall Claude Bernard's observation of the paralytic secretion which occurs in the submaxillary gland after all nerve connections of the submaxillary ganglion with the cerebro-spinal axis are severed, and which finally leads to functional destruction of the gland. I also recall the fact that certain fibres or nerves of the cerebro-spinal system exhibit a marked tonus upon certain vegetative functions as well as upon the cerebro-spinal centres.

Space does not allow us to discuss here at length the nature of the relationship which exists between the sympathetic and the cerebro-spinal systems; we can only point out some principal facts. It is a characteristic of the vegetative functions, including in general the action of non-striated muscles, that while they can be stimulated to strong action by emotions—as evidenced by the blush of shame, the diarrhœa of fright, etc.—they cannot be influenced directly by the will. An exception to this rule was observed by Bechterew in a hysterical patient who by force of will could change the size of her pupil, and it is furthermore claimed by some persons that they can voluntarily arrest the action of their heart—an assertion which, it is true, still needs confirmation. However, on the whole, the rule holds good.

Another characteristic of vegetative or visceral functions is the fact that under normal circumstances visceral nerve stimuli do not rise to consciousness, although we do become conscious of them in case of increased visceral action; for instance, we feel palpitation when, owing to exertion, the heart beats with increased vigor and frequency, or in case of sensory hyperexcitability of central origin, such as occurs in hypochondriasis and neurasthenia. But even then the sensation is of a vague, indefinite character. This vagueness of visceral sensation is probably one of the factors preventing direct voluntary influence on vegetative functions. Another factor is probably the lesser excitability of the non-striated muscle as compared with that of striated muscle. A third factor might be sought in the manner of connection of the nerve endings in the vegetative organs with the parts which they supply (glandular cells, non-striated muscular fibres), and another one in the more numerously linked chain of neurones that has to be passed till a motor nerve impulse reaches a vegetative organ, as compared with the chain of fewer links to be passed by a motor impulse in the case of a voluntary striated muscle. (For further details consult the monograph of Onuf and Collins.)

General Physiological Remarks.—The essential influence which the sympathetic system exercises on the vegetative life of the organism has been amply demonstrated in the foregoing review. Inasmuch as some vegetative functions are exquisitely vital, we may say also that the sympathetic system possesses in high degree vital functions. This is confirmed by the fact that in very young cats lesions of the important parts of the sympathetic invariably proved fatal. Even if the animals outlived such operations as extirpation of the semilunar ganglion or removal of the stellate ganglion or resection of the lower part of the thoracic sympathetic, they invariably died, and usually a few hours or days after the operation (Onuf and Collins).

The death of many animals during the operations was caused by pulling upon the sympathetic nerve or by bruising a sympathetic ganglion. This was especially the case in operating to remove the stellate ganglion. Although the animal would be breathing vigorously and freely immediately before, as soon as the stellate ganglion was pulled upon or as soon as its connections with the thoracic sympathetic nerve were severed, respiration suddenly became arrested and the animal promptly died.

Older animals—that is, cats which had reached the age of five or six weeks—stood these lesions much better, and three of them lived for from three to five months after the operation, when they were killed.

In man the upper cervical ganglion of the sympathetic has been frequently removed of late for the relief of glaucoma, and no deleterious effects on the heart action or respiration were noted. However, the patients thus operated upon were usually adults.

A fact recently brought out by Cleghorn deserves mention here. Cleghorn found that glycerin extracts of sympathetic ganglia, when injected into the femoral or jugular vein, caused a fall in blood pressure which was not observed if glycerin extracts of spinal ganglia, or of spinal cord or brain matter, or of nerve or abdominal tissue, were injected instead. Cleghorn seems recently to connect this vascular effect of the glycerin extracts of sympathetic ganglia with the presence in the latter of large polygonal cells, discovered by Stilling, which cells stain deeply in chromic acid and are found also in the suprarenal capsules.

In concluding this subject, attention is called once more to the remote effects of lesions of the sympathetic, these being often late in their appearance and showing a tendency to progression, as was the case with the digestive and respiratory disturbances following removal of the stellate ganglion or of part of the thoracic sympathetic nerve.

Representation of the Sympathetic in the Spinal Cord and Brain.—The rôle of the rami communicantes and their homologues, in establishing a connection between the cerebro-spinal and sympathetic systems, has been amply discussed in previous paragraphs (see pages 580 and 581). It remains now to describe in detail the manner of representation of the sympathetic in the spinal cord and brain.

From a study of the degenerations following resection of portions of the gangliated cords, Dr. Collins and the writer (see the monograph above mentioned) came to the following conclusions regarding the course and spinal representation of the afferent and efferent fibres of the sympathetic nerve proper in the cat:

1. Most, or at least many, of the afferent (sensory) fibres of the sympathetic nerves do not originate from cells of the spinal ganglia, as Kölliker claims, but must have their cells of origin within the ganglia or plexuses of the sympathetic system.

2. The chief terminal station for the afferent fibres of the sympathetic is *Clarke's column*, the said fibres probably ending there around the cells of this column. Other terminal stations of such fibres are probably the lateral horn and the zone between the anterior and posterior horns which we called the intermediate zone. The fibres probably terminate around the large cells of these regions.

3. Clarke's column, besides being a terminal station for afferent fibres from the vegetative organs, may be instrumental also in conducting sensory stimuli from the muscles, tendons, joints, and bones to the cerebellum, being thus largely concerned in maintaining equilibrium.

4. The afferent fibres of the sympathetic nerve after entering the spinal cord probably send reflex collaterals to the nuclei of the efferent fibres of the sympathetic (see Fig. 4581).

5. The afferent fibres of the *lumbar* sympathetic nerve, entering the spinal cord by way of the posterior roots, after having arrived at Clarke's column, evidently describe a longitudinal course upward (cephalad) to terminate around cells of a considerably higher level (see Fig. 4579).

6. The afferent fibres coming from the ganglia of the lower half of the thoracic sympathetic take on the whole a rather horizontal course in the spinal cord, to become connected with spinal cells of the same level, but part of these fibres probably descend either in the spinal cord or in the sympathetic nerve through the distance of one or more segments before reaching the cells around which they terminate. This is illustrated diagrammatically in Fig. 4580.

7. Many of the afferent fibres derived from the stellate ganglion probably make a long descent in the spinal cord or possibly in the sympathetic nerve, becoming connected partly with the same cells with which the fibres from the lower portion of the thoracic sympathetic nerve form connections (see also Fig. 4580).

8. The efferent (motor, secretory, inhibitory, etc.) fibres of the sympathetic probably take their origin from the cells of the following cell groups of the spinal cord: (*a*) The paracentral group; (*b*) the small cells of the lateral horn; and (*c*) probably the small cells of the zone situated between the bases of the anterior and posterior horns (intermediate zone). The situation of these groups is diagrammatically illustrated in Fig. 4581. That most (or all) of these fibres do not pass uninterruptedly to the peripheral organ innervated by them, but terminate in some ganglion of the sympathetic, and that from there a new set of neurones originates, giving rise to "sympathetic" fibres which pass to the periphery, has been discussed in other paragraphs, chiefly pages 580 and 581.

9. The paracentral group has possibly a vascular function.

10. The pathway of the efferent fibres of the sympathetic is probably similar to that of the afferent fibres as outlined under 5, 6, and 7; with this difference, that most of them pass through the anterior and not the posterior roots, and that they conduct the impulse in the opposite direction to that of the afferent fibres.

11. The spinal representation of both the afferent and the efferent fibres of the sympathetic nerve is probably bilateral.

12. The homologon of Clarke's column for the oblongata is probably a large-celled nucleus accompanying the so-called solitary or respiratory bundle at its ventro-lateral border.

13. The homologon of the paracentral group for the oblongata is evidently the so-called dorsal vagus nucleus, called also vagoglossopharyngeal nucleus, situated at the floor of the fourth ventricle.

It probably has the function of supplying the non-striated muscles innervated by the pneumogastric nerve, while those nerve fibres of this nerve which supply striated muscles probably originate from the nucleus ambiguus.

The relations between: (1) the ninth, tenth, eleventh nerves, (2) solitary bundle, (3) vagoglossopharyngeal nucleus, and (4) nucleus ambiguus are illustrated in Fig. 4582.

14. Higher up in the cerebral axis the paracentral group (of the spinal cord) is possibly and even probably represented by the vesicular cells accompanying the so-called cerebral fifth root (known formerly under the name of the descending fifth root) and by the cells of the substantia ferruginea.

To the views arrived at by Gaskell by a most ingenious method we can only allude here, giving his conclusions as to the centres for the efferent fibres (including those of the sympathetic) in the form of a table:

A. (Cells of the anterior horns.) Nucleus of efferent nerves to somatic muscles.	Represented in the medulla oblongata by the hypoglossal nucleus.
B. (Large cells of lateral horns.) Nucleus of efferent nerves to striated splanchnic muscles.	Represented in the medulla oblongata by the nucleus ambiguus (motor vagus nucleus).
C. (Cells of Clarke's columns.) Nucleus of anabolic (inhibitory) nerves to splanchnic glandular system and to muscles of viscera.	Represented in the medulla oblongata by the nuclei at the floor of the fourth ventricle, known as the accessory and the dorsal vagus nuclei.
D. (Solitary cells of posterior horn.) Nucleus of motor nerves to muscles of viscera.	No mention made respecting their possible representation in the medulla oblongata.
E. (Small cells of lateral horn.) Nucleus of katabolic (motor) nerves to splanchnic glandular system and to muscles of vascular system.	

This shows that in many respects Gaskell had come to conclusions similar to those reached by Dr. Collins and the writer.

To enter on the conclusions of other workers in this field, for instance Mott, the space allotted to this subject does not allow.

B. Onuf (*Onufrowicz*).

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SYMPATHETIC NERVOUS SYSTEM, DISEASES OF. (GENERAL.)—A systematic discussion of the diseases of the sympathetic nervous system is, at the present state of our knowledge, not feasible. The anatomy, physiology, and pathology of this part of the nervous system are still quite obscure.

At the bedside symptoms referable to and explicable by disordered function of the vegetative neural mechanism are encountered quite frequently. These symptoms are mainly expressions of exaggerated, diminished, or perverted trophic, circulatory, secretory, viscero-sensory, and viscero-motor functions.

Diseases of the sympathetic nervous system may be divided into two large groups:

1. Primary (idiopathic).
2. Secondary (deuteropathic).

Many general diseases were, and some are still, looked upon as expressions of primary functional or structural derangement of the sympathetic nervous system. Such are, for example, migraine, angioneurotic œdema, Basedow's disease, facial hemiatrophy, erythromelalgia, scleroderma, Raynaud's disease, and Addison's disease. These and other trophic syndromes are frequently interpreted as primary diseases of the sympathetic nervous system.

The familiar syndrome of irritation or paralysis of the cervical sympathetic is a good illustration of a secondary affection. Very little is known of primary or secondary diseases of the thoracic part of the sympathetic chain. Oppenheim records a case which presented during life a unilateral œdema, the explanation of which was found in an abscess near the thoracic vertebral column. The writer published a case of abscess formation implicating the thoracic chain of the sympathetic, which presented rather obscure symptoms during life (*Med. Rec.*, June 16th, 1900).

The rôle that diseases of the thoracic part of the sympathetic chain may play in the pathology of asthma and cardiac neuroses is entirely unknown.

The relation of the abdominal sympathetic to the pathogenesis of Addison's disease, diabetes, colica mucosa, is still under discussion. Symptoms referable to disorder of the functions of the sympathetic nervous system are frequently accompaniments of almost any organic lesion of the cerebro-spinal nervous system.

The gastric and other visceral crises arising in the course of tabes, the trophic manifestations accompanying this disease as well as syringomyelia, are good illustrations in point.

Joseph Fraenkel.

SYMPATHETIC OPHTHALMIA includes two quite distinct diseases—sympathetic inflammation, or sympathetic ophthalmitis; and sympathetic irritation. These conditions are liable to arise in a previously healthy eye, after the fellow-eye has been injured and has become the seat of chronic inflammation due to such injury. In addition to these two definite forms of disease, to be described below, there are cases in which a blind degenerated eye seems to exert an unfavorable influence upon the fellow-eye.

Many surgeons believe that any blind and degenerated eyeball should be removed, if the fellow-eye becomes impaired by chronic progressive disease. Thus, if one eye presents an absolute glaucoma and the other a beginning glaucoma, the prospect of arresting the process in the latter may sometimes be improved by removing the blind eye. Or if one eye be blind with general detachment of the retina and softening of the globe, it is thought that choroidal degeneration or cataract affecting the other may be favorably influenced by removal of the blind eye. Such a belief in the dangers of sightless, degenerated eyeballs is not universal and should not be acted upon unless there is some evidence of disease in the second eye or danger of sympathetic inflammation. But if other disease of the better eye arises, the possibility of influencing it favorably by removal of a sightless degenerated stump should be carefully considered.

It is possible that in some cases inflammation of the uveal tract not caused by injury may extend from one eye to the other. But this is not certainly established. It is convenient to speak of the injured and primarily inflamed eye as the *exciting eye*, and of the other as the *sympathizing eye*.

SYMPATHETIC OPHTHALMITIS.—(Synonyms: Sympathetic uveitis, Cyclitis, or Irido-cyclitis, Malignant Uveitis, or Migratory Ophthalmia.) This is an inflammation involving chiefly the uveal tract of the eye, but liable to extend to all the tissues of the eyeball, running a chronic course marked by repeated relapses, and ending in the majority of cases in complete blindness.

Causes.—Sympathetic inflammation is caused by non-purulent traumatic inflammation in the uveal tract of the fellow-eye. Injury of one eye unattended with uveal inflammation of the injured eye does not cause sympathetic uveitis. Uveal inflammation not due to traumatism does not excite this disease. Injuries to the eyeball, which are followed by severe purulent uveitis or panophthalmitis, are not likely to excite sympathetic inflammation. Disease in other organs may cause metastatic inflammation of the eye, but not the form of inflammation now under consideration. The character of the wound of the exciting eye greatly influences the liability to sympathetic disease.

The lodgment of a foreign body within the eyeball constitutes the most dangerous form of injury, unless the eye be promptly destroyed by suppuration. Yet the character of the foreign body and the structure in which it is lodged modify its evil influence. Minute aseptic foreign bodies sometimes remain in the eyeball indefinitely, without causing serious impairment of the injured eye or danger of sympathetic ophthalmia in its fellow. They are least dangerous when lodged in the crystalline