XXVI. *On the Nerves of the Face; being a second paper on that subject.* By Charles Bell, *Esq. Fellow of the Royal Society.*

Read May 28, 1829.

I HAVE to beg the indulgence of the Society to some minute details of anatomy, for the sake of those deductions which can be attained by no other means: and that a zeal for its cultivation may be preserved among us. There is an obvious practical benefit derived from anatomy, but the public do not comprehend its importance as a science. It is to the Royal Society that those who prosecute this science must look for countenance in their slow and painful investigations.

Nine years ago, at the request of our late President, I submitted to the Society a paper on the Nervous System; in which I arranged the nerves strictly according to the anatomy, and illustrated the principles of the arrangement, by exhibiting the different functions of the Nerves of the Face. On presenting a second paper on the same part of the nervous system after so considerable a lapse of time, there will be some novelty both in the facts and in the illustrations; yet I have more gratification in showing that after the most minute inquiries in different countries, my positions drawn from the anatomy have been admitted, and my reasoning on the experiments, with one exception, found to be correct. Confident in the accuracy of my deductions from the anatomy of the fifth nerve, I had attributed to one of its branches a function which belongs to another branch of the same nerve. The subject will form a part of the present paper.

After the announcement of the facts in my first paper, the inquiry became interesting from its application to medical practice. I must take another opportunity of thanking those gentlemen who have so liberally afforded additional proofs of the truth of my principles. I must restrict myself in refer-

ring to them here, since I am desirous that the Society's Transactions should contain only the philosophical part of the inquiry.

The system of WILLIS, of which we have an elegant account in the posthumous works of Dr. BAILLIE, prevailed universally in the schools when I entered on these inquiries. In opposition to that system I demonstrated that the nerves hitherto supposed to possess the same powers, consisted of filaments having different roots, and performing different functions. I found myself embarked in this investigation, from observing the course which the nerves took in their distribution through the body. Conceiving that the devious course and reunion of the nerves were for a purpose, I sought in their origins for the cause of their seeming irregularity. It was discovered that the roots of the nerves arose from distinct columns of nervous matter, and that on these columns depended their different properties. Those which were called the common nerves, that is, the nerves which arise from the spinal marrow, thirty in number, were found to consist each of two nerves derived from distinct columns, one for sensation and one for motion. In the further pursuit of this subject, there was reason to conclude that the spinal marrow contained not only the columns for bestowing sensation and motion, but also another column, the office of which was to combine the actions of respiration. I then drew the attention of the Society to the course of the fifth nerve of the brain according to WILLIS. I showed that it had the same double root as the spinal nerves, that it had a ganglion, and that part of the nerve passed free of the ganglion; and that from all these points of resemblance, it was to be considered as the anterior or superior of the spinal nerves, of that system which is called symmetrical, and which ministers to the same functions in all classes of animals, bestowing sensibility and the locomotive powers, but deficient in those filaments which command the respiratory motions. I am particular in restating this, because from time to time it has been reported that I had abandoned my original opinions; whereas every thing has tended to confirm them.

From the general view of the nervous system, I drew attention to the superadded or irregular nerves. Having shown that the original or symmetrical system of nerves, of which the fifth was one, had no power over the motions of respiration, and that the human countenance in all its motions, with the exception of mastication, bore relation to the actions of respiration, it was

therefore required that another nerve besides the fifth, should be sent to the face. Having shown also that the roots of the fifth nerve were distant from that column of nervous matter which gives origin to the nerves of the respiratory system, and that it could not therefore minister to the motions of the face which are connected with respiration; and that another nerve, the portio dura, having its root in common with the nerves of respiration, took its course to the face,—the subject was prepared for experiment.

By experiments on the nerves of the face these three things were proved: First, that the sensibility of the head and face depended on the fifth pair of nerves. Secondly, that the muscular branches of the fifth were for mastication: and in the Third place, it was proved that the portio dura of the seventh, or respiratory nerve of the face, controuled the motions of the features, performing all those motions, voluntary or involuntary, which are necessarily connected with respiration;—such as breathing, sucking, swallowing, and speaking, with all the varieties of expression.

Reserving the details, I shall now state shortly the occurrences which I have witnessed since the publication of that paper; as they afford convincing proofs of the correctness of these opinions.

The first instance was in a man shot with a pistol ball, which entered the ear and tore across the portio dura at its root. All motion on the same side of the face from that time ceased; but he continued in possession of the sensibility of the integuments of that side of the face.

The next instance was in a man wounded by the horn of an ox. The point of the horn entered under the angle of the jaw and came out before the ear, tearing across the portio dura. He remains now a singular proof of the effects of the loss of function in the muscles of the face by this nerve being divided. The forehead of the corresponding side is without motion, the eyelids remain open, the nostril has no motion in breathing, and the mouth is drawn to the opposite side. The muscles of the face by long disuse are degenerated, and the integuments of the wounded side of the face are become like a membrane stretched over the skull. They have lost their firmness, and the flesh under them is wasted, with the exception of certain muscles, the reason of which will be understood on perusing the anatomical description in the present paper. In this man the sensibility of the face is perfect. The same nerve (portio dura)

has been divided in the extirpation of a tumour from before the ear, and the immediate effect has been horrible distortion of the face by the prevalence of the muscles of the opposite side, but without the loss of sensibility; and that distortion is unhappily increased when a pleasurable emotion should be reflected in the countenance.

These facts are so distinct, that I cannot presume to detain the Society with the instances of the lesser defects which I have witnessed from the more partial injuries or temporary diseases of the nerve;—such as distortion of the features produced by glands pressing on this nerve, paralysis from suppurations in the ear affecting the nerve in its passage, or temporary derangement disturbing one or more of its functions.

As to the fifth nerve, the facts are equally impressive, and correspond with our former experiments and opinions. By a small sacculated tumour affecting the roots of this nerve, the sensibility was destroyed in all the parts supplied by its widely extended branches; that is, in all the side of the head and face and the side of the tongue, whilst the motion of the face remained. Two circumstances affecting this nerve have occurred with most curious coincidence in the symptoms. By the drawing of a tooth from the lower jaw, the nerve which comes out upon the chin to supply one half of the lip was injured, and exactly this half of the lip was rendered insensible. When the patient put his mouth to a tumbler he thought they had given him a broken glass! Precisely the same thing occurred from the division of that branch of the fifth nerve, which goes to one half of the upper lip. A gentleman falling, a sharp point entered his cheek and divided the infra orbitary nerve: the effect was loss of sensation without loss of motion, in that half of the upper lip to which the nerve is distributed. The remarkable circumstance was, that this individual made the same remark when the cup was put to his lip:—that they had given him a broken one! The part of the cup which was placed in contact with the insensible portion of the lip appeared to him to be broken off.

I have had two or three instances before me of disease affecting the ophthalmic branch of the fifth nerve, and producing total insensibility of the eye and eyelids, without loss of vision; whilst the eyelids continued to be closed and the eyebrow to be moved by the influence of the portio dura of the seventh nerve.

Such are a few of the facts which have been reaped from a patient reliance on the correctness of my first deductions, and I would now urge them in proof of the importance of reasoning upon the anatomy. All these nerves have been repeatedly divided, by almost every surgeon of eminence in the three kingdoms. Although some have performed the operation of dividing the nerves frequently, and one eminent gentleman had done it six times on the face of the same man, all these operations have been performed without giving rise to the suspicion that these nerves bestowed different properties. Even now, so slow is the progress of improvement, it is stated by a surgeon that he will not hesitate to cut the portio dura in the case of tic douloureux. My duty is performed when I give publicity to the facts which prove that horrible distortion of the whole countenance, the loss of distinct articulation, the loss of expression, the loss of motion of the eyelids, and consequent inflammation of the eye, must follow such an operation.

Much has been said in favour of experiments when made by men who are positively without any expectation of the result, or, as they affirm, are unbiassed. The only instances of this that I can allow, are when the surgeon cuts the nerves of the face in a surgical operation. In such operations as these for tic douloureux, he is indeed unbiassed; and we have seen the result, that after fifty years of such experience we remained quite ignorant of the distinctions in these nerves. But on the other hand when attention is roused to inquiry by aantomy, facts are obtained of the utmost importance both to the knowledge of disease and to the safe practice of surgery.

Of the Motor or Manducatory portion of the Fifth Nerve.

The fifth nerve is usually called Trigeminus, from piercing the skull in three grand divisions. But when it has been shown that it is composed of two distinct roots having different functions, the accidental circumstance of its divisions passing through the bones yields in importance to another inquiry, How is the muscular portion of the nerve distributed?

Since the publication of my first paper this inquiry has assumed importance; although the principal facts of the anatomy were known to Wrisberg, Santorini, Paletta, Prochaska, and Sœmmerring. But in no author is the ana-

tomy of the motor portion of the nerve traced with sufficient minuteness, or regard to the distinct uses of the muscular and sensitive divisions.

The motor division of the fifth nerve passes under the Gasserian ganglion, and free of it. It is not seen when we look from above, as in the plates of Monro. When the nerve is turned up and dissected, this portion is seen to form about a fifth part of the whole nerve. It is tied to the larger portion before advancing to the ganglion, by filaments which have been sometimes taken for nerves.

Having passed the ganglion, it attaches itself slightly to the superior maxillary nerve, but this is apparently a membranous connection only*. The nerve itself joins the third grand division after passing the foramen ovale. At this point the muscular and sensitive portions of the nerves are matted together, and form a mass which between the fingers feels like a knot†. There is, however, no red and fleshy-like matter interposed here, as in the Gasserian ganglion of the trunk of the nerve. But the filaments of both portions of the nerve are here so complexly and intimately combined, that all the branches which go off after this union are compound nerves, and have motor filaments in their composition.

It is, however, equally obvious that the gustatory division of the nerve which descends from this mass, has not the muscular portion given to it in that abundance which those branches have which take their course to the muscles of the jaws. The mandibulo-labralis, which also descends from this plexus, lies nearer the motor portion, and has a more distinct addition given to it than the gustatory nerve.

This motor or muscular portion which we are tracing, sends off no branch either in its course under the great ganglion, or after passing it about half an inch. But when it has arrived at the point of union with the ganglionic portion, the filaments become interwoven; and from this place the nerves are

* Gerardi, commenting on Santorini, says that the anterior root (the motor) does give filaments to the superior maxillary division of the fifth. Prochaska (de Structura Nervorum) gives two views, Tab. ii. fig. v. vi. which represent an actual union of the anterior root and the superior maxillary nerve. In the plate, however, the twigs seem rather to go from the ganglionic into the motor division.

† Santorini says, it is a plexus like a ganglion, "in plexum vere ganglioformem mutatur."

compound, and go off diverging to their destinations. First, there are sent off nerves to the temporal, masseter, and pterygoid, muscles, also to the buccinator muscle. The temporal muscle receives a large and appropriate nerve. The nerve to the masseter passes between the coronoid and condyloid processes of the lower jawbone; but before going into the muscle it sends branches to the temporal muscle. The pterygoid muscles have each their appropriate nerves coming direct from this plexus.

Ramus Buccinalis Labialis.

This is a remarkable branch which arises from the same source, and goes to the cheek and lips. This nerve where it lies on the external pterygoid muscle sends one more branch to the temporal muscle; it then divides, one branch enters the buccinator muscle, and another is prolonged forwards. The division to the buccinator muscle is tortuous, which is no doubt a provision for its being undisturbed by the free motion of the cheek; its minute branches may be traced until lost among the muscular fibres, whilst others penetrate to the lining of the cheek. The prolonged branch is the labial division; it runs nearer the alveolar processes of the lower jaw, and becomes so superficial as to admit a union with the portio dura: from thence passing under the facial artery it may be traced into the triangularis or depressor anguli oris, the levator labiorum communis, and the lateral portion of the orbicularis oris.

In the distribution of the buccinalis labialis to the muscles of the mouth, it is joined, as I have said, by branches of the portio dura; and nothing is more striking than the manner in which this latter nerve passes over the masseter, a muscle of the jaw, to be profusely given to the muscles of the lips.

There is one more branch important to the physiology of the fifth nerve. At the root of the mandibulo-labralis (where it is sent off from the junction of the muscular and ganglionic portions), a small nerve takes its origin. This branch runs parallel to the greater nerve till it enters the foramen in the lower jaw; here it seems to enter, but does not; it takes a course on the inside of the jaw to arrive at its final destination, the mylo-hyoideus and the anterior belly of the digastricus, that is, to those muscles which open the mouth by drawing down the jaw.

We may for a moment interrupt our particular inquiry, to notice that all muscular nerves, and consequently the muscular divisions of the fifth nerve, form a plexus. The plexus, formed by the motor and ganglionic divisions of the fifth nerve before they diverge to the muscles of the lower jaw, corresponds with the plexus formed on the nerves sent to other classes of muscles. Even that branch of the third division of the fifth nerve which comes out before the ear, joins the portio dura in a plexus*; and this is the reason of that sensibility evinced in the facial nerve in making experiments upon it.

The form of the fifth nerve, and its resemblance to the spinal nerves, had struck some of the best continental anatomists. But as they had made no distinctions in the functions of the roots of the spinal nerves, so neither did they imagine any difference in the roots of the fifth nerve, and therefore no consequence resulted from having observed this resemblance. This part of the anatomy, together with the whole minute relations of the nerves, was a dead letter, and led to no inference.

But now resuming the course I have hitherto followed, the anatomy of the fifth nerve points to curious results. We see that the motor division of this nerve goes first to the muscles which close the jaw and give it the lateral or grinding motions. Secondly, we see that it is distributed to the muscles of the cheek, which place the morsel under the operation of the teeth; and thirdly, we find it going to the muscles which open the jaws.

We proceed to the second method of proof, by experiment. Does the fifth nerve move the jaw? is it indeed the manducatory nerve as suggested by the anatomy? Let the following experiments determine the fact.

Experiment I.

The root of the fifth nerve being exposed in an ass and irritated, the jaws closed with a snap.

Experiment II.

The fifth pair being divided in an ass, the jaw fell relaxed and powerless.

If we consider the action of mastication, we shall see what the consequence would be, were there no accordance between the motions of the lower jaw and

* See the adjoined plate.

the cheeks. Conceiving that there must be such an accordance, and contemplating the roots of the fifth pair and their distinct functions, I had imagined that this office was performed by the branches of the second division of the fifth. But finding that the connection between the motor root and the superior maxillary nerve proved to be only by cellular texture, and considering the affirmation of M. MAGENDIE and those who followed him, that the infra-orbitary branch had no influence upon the lips, I prosecuted with more interest the Ramus Buccinalis Labialis. And nobody, I presume, will doubt that the distribution of this division confirms the notions drawn from the anatomy of the trunk,—not only that the fifth nerve is the manducatory nerve as belongs to the muscles of the jaws, but also that it is distributed to the muscles of the cheek and lips to bring them into correspondence with the motions of the jaws. Let us take in illustration the articulation of the bones. In the joints the muscles are attached to the capsular membrane in such a manner as to draw it from between the bones and adapt it to the degree of flexion of the joint. If the cheek were a passive membrane like the capsule of a joint, it would have required some such mechanical connection with the jaw or its muscles, as might have drawn it from between the teeth in the motions of mastication. But being a muscular part, to bring it into just relation with the motions of the teeth, it must have an accordance through nerves, and act in sympathy;—relax when the jaws are apart, and contract when they are closed. I think therefore we may perceive why a branch of the motor nerve of the muscles of the jaws sends a division to the muscles of the cheek and to the angle of the mouth.

By such a process of reasoning we see also why a branch of the same nerve should prolong its course under the chin to the muscles which are opponents to those which close the jaw.

In short, the motor portion of the fifth nerve sends no twigs with the ophthalmic division, nor the superior maxillary nerve, but only with the lower maxillary nerve. To the muscles of the lower jaw alone which are in action during mastication, and to the muscles necessarily associated in that action, the manducatory nerve is distributed.

It remains only that we observe what takes place in man, and compare the circumstances with experiments on brutes.

I was consulted in the case of a lady with an uncommon disease in the side of the head: the description of her condition puzzled me very much; there was so much said of tumours with pulsation on the head and face. But when I saw and examined her, the mystery disappeared; she had powerful spasms of the temporal and masseter muscles, which rose and swelled, under the excitement of a disease of the cheek, and with a pressure of the jaws so powerful as to displace the teeth. During this violent spasm of the muscles supplied by the fifth nerve, the motions of the features were free and unconstrained under the influence of the portio dura of the seventh nerve.

I have the precise counter-part to this morbid condition of the muscles of mastication in the case of a poor man now under my care. He has a disease affecting the fifth nerve of the left side, attended with the loss of sensibility of the side of the face and of the surfaces of the eye. In him there is no motion of the muscles of the jaw of the affected side. In chewing, the action is only on the right side of the head; the masseter muscle and temporal muscle of the left side do not rise or bulge out as in their natural actions; but his command over his features is perfect through the operation of the portio dura. It appears, therefore, that the disease of the fifth nerve, which has destroyed the sensibility on one side of the face, has caused a loss of motion in the muscles of the jaw on the same side.

A more frequent occurrence establishing the distinction of motions influenced by the fifth and seventh nerves, is presented in the case of paralysis of the portio dura; for then all the muscles waste but those supplied by the fifth. In the case referred to, of the man wounded by the horn of an ox, in whom the portio dura was torn, and who had the skin of his forehead, side of the nose, cheek and lips, deprived of all fleshiness and substance, and in fact wasted to mere skin, the muscles of the jaw were entire and prominent; and on introducing the finger into the mouth and making him imitate the motions of mastication, a weak contraction could be felt in the cheek*.

These facts close the evidence of the fifth nerve being a double nerve; not only the nerve of sensibility to the head and face, but a muscular nerve to the muscles of the jaws, active in mastication, and otherwise useful in all animals

* How often a question has occurred as to this motion in the cheeks, may be seen on referring to cases, p. 123, Exposition, &c. and p. 57, Appendix, 1st edition.

whose jaws are prehensile and used as hands. This curious fact, originally drawn from the anatomy and now confirmed by it, had nearly been obscured by experiment; since the external branches of the fifth nerve, those most exposed to the experimenter, are not muscular.

I am bound to acknowledge here the correction by M. MAGENDIE, in regard to the office of the suborbital division of this nerve, since it has given occasion to the revisal of the anatomy*.

We were involved in great confusion by the discovery of new branches of nerves and of ganglions, through which we had no guide, until we formed a correct arrangement of the whole system. It is satisfactory to find that the ideas first suggested by a comparison between the roots of the nerves and their complex distribution in the face and neck are correct, when tried by a minute investigation of the internal nerves of the head; and that the conclusions drawn from the anatomy, are confirmed both by experiment and by a knowledge of the effects of injuries and of disease in the human frame.

ADDITIONAL NOTE.—As the most important fact in this paper is that ascertained by experiments on the fifth nerve, I am bound to say by whom they were made, and for what purpose.

To my late brother-in-law Mr. JOHN SHAW, whom I educated, I have been indebted through the whole of this inquiry. He had long been acquainted in the most intimate manner with my pursuits. He had repeated my experiments on the roots of the spinal nerves, confirming the results,—that the anterior roots when irritated caused the muscles to contract, and that the posterior roots had no such influence.

He assisted me in my experiments on the nerves of the face, which were for the purpose of establishing that the fifth pair resembled the nerves of the spine, and at the same time proving, what was incomplete from the experiments on the spinal nerves, that a ganglion on one of the roots of a nerve is no cause of

* M. MAGENDIE says, "Le résultat que nous avons obtenu s'accorde parfaitement avec celui que nous venons de rapporter, à l'exception toutefois de l'influence de la section de sous-orbitaire sur la mastication, influence qui n'a pas été evidente pour moi."—Journal de Physiologie, 1821.

interruption to sensation, but the sign that it bestows sensibility; making certain what could be only assumed from the experiments on the spinal nerves.

But he was acquainted also with my opinions drawn from the distribution of the nerves in the body contrasted with the anatomy of their roots. And when the correctness of these opinions was established by experiment, he let no opportunity pass of advocating and supporting them. In collecting information and making dissections he was ever active, as all the real students educated with him will testify. It was in the fervour of his zeal that he went to Paris and explained the arrangement by which I distinguished the nerves, and repeated my experiments with M. MAGENDIE and others at Charenton near Paris in 1821.

At this time an idea was thrown out that the fifth nerve was no more than the sensitive nerve of the face accidentally separated from the muscular nerve (the portio dura). Perceiving that if this notion prevailed we should be thrown back into our former state of confusion, and to put the matter beyond all question, Mr. SHAW performed those experiments which are contained in this paper,—experiments which in the gentleness of his nature he would have hesitated to make from their severity, but for their being imperatively called for.

Had Mr. SHAW lived, this subject would have been further advanced. Whilst his excellent judgement and indefatigable exertions aided me in every difficulty, his gratification in witnessing the progress of these inquiries was a reward beyond what I have now to look for.

Explanation of Plate VIII.

In this figure the superficial nerves of the face are turned off, and the distribution of the third division of the fifth to the muscles of the jaws and cheek exposed.

A. The portio dura of the seventh or respiratory nerve of the face coming out from the stylomastoid foramen; the principal branches are cut and folded forwards.

B. The trunk of the portio dura of the seventh, dissected off the face and pinned out, while it is left at its connections with the branches of the fifth on the cheek and lips.

Drawn by C. Bell.

Engraved by F. Basire.

Fig. 3.

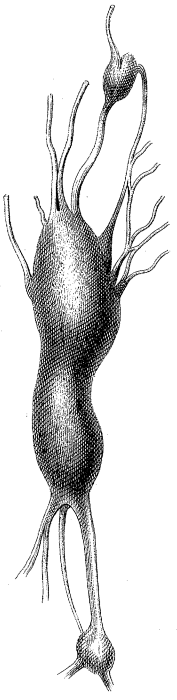

Fig. 2.

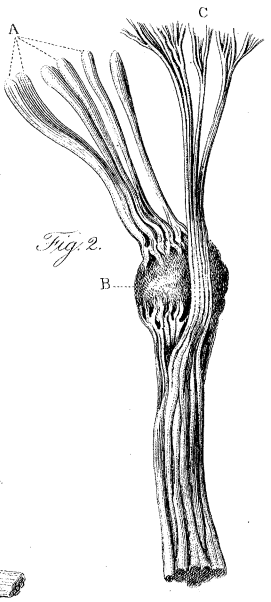

Fig. 1.

C. The branch of the third division of the fifth nerve, which joins the plexus of the portio dura before the ear. Some experimenters, ignorant of this junction of a sensitive nerve with the muscular nerve, have occupied themselves with experiments to ascertain the degree of sensibility of the portio dura.

D. In this figure the masseter muscle is dissected from the jaw-bone and lifted up to show D, the branch of the fifth pair of nerves going into the muscle.

E. The Ramus Buccinalis-labialis, that branch of the fifth nerve which goes to the buccinator, triangularis, levator labiorum, and orbicularis muscles.

F. That branch of the fifth nerve which separating from the mandibulo-labralis goes to the muscles which depress the lower jaw.

G. The suborbitary nerve, a branch of the fifth nerve.

H. The mandibulo-labralis, a branch of the fifth nerve coming out from the bone to the muscles and integuments of the lip and chin.

I. A branch of the fifth nerve descending from the orbit.

D, E, F, are muscular branches of the fifth nerve, and are motor nerves. C, G, H, I, are sensitive branches of the same nerve which join the branches of the portio dura in its universal distribution; and although these branches of the fifth enter the muscles, they possess no power over their motions. B is the portio dura, which, though taking the same course with the last, is for a different purpose; while it is a motor nerve, by its association with the respiratory nerves, it is enabled to excite those actions of the face and lips which are necessarily connected with the act of breathing.

Explanation of Plate IX.

Fig. 1. Represents the fifth nerve dissected out and seen on its lower surface.

A. The posterior or sensitive root before it forms the ganglion.

B. The Gasserian ganglion.

C. The anterior or motor root of the nerve passing the ganglion.

D. The third or lower maxillary division of the fifth nerve.

E. The motor portion joining the lower maxillary nerve and forming a plexus with it. From this plexus go off the muscular nerves to the muscles of the jaw, viz.

1. Temporalis.

2. Massetericus.
3. Buccinalis labialis.
4. Pterygoideus.
5. Mylo-hyoideus.

F. Division which joins the portio dura.

G. Mandibulo-labralis.

H. Gustatory nerve.

I. The chorda tympani.

Fig. 2. This figure represents the ganglion on one of the spinal nerves, to show its resemblance to the ganglion of the fifth nerve in every particular.

A. The posterior or sensitive root of the nerve.

B. The ganglion formed upon the posterior root.

C. The anterior or motor root of the nerve; this arises in minute branches which join to form the larger subdivisions, whilst the posterior root is composed of simple and abrupt portions. This division joins the sensitive division beyond the ganglion exactly in the same manner that the motor portion of the fifth joins the lower maxillary nerve.

Fig. 3. Represents one of the ganglions of the sympathetic nerve to show how different it is from those on the symmetrical system of nerves. In fig. 1 and 2 the nerve on entering the ganglion and escaping from it, is separated into branches in a manner very different from the mode in which the sympathetic nerve joins or forms its ganglions*.

* Authors who have treated of the anatomy of the ganglions, have not distinguished between the two classes of ganglions as belonging to the sensitive and sympathetic systems of nerves.