XXIII. *Of the Nerves which associate the muscles of the Chest, in the actions of breathing, speaking, and expression. Being a continuation of the paper on the Structure and Functions of the Nerves.* *By* CHARLES BELL, *Esq. Communicated by Sir* HUMPHRY DAVY, *Bart. LL. D. P. R. S.*

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IN a former paper an examination was made of the nerves of the face; that part of the system was taken, as proving in a manner the least liable to exception, that two sets of nerves, hitherto undistinguished, possessed distinct powers; and that very different effects were produced when the muscles and integuments were deprived of the controuling influence of the one or of the other of these nerves. In that paper it was shown, that parts remote in situation, were yet united by the closest sympathy with the lungs. That by a division of one nerve, these organs could be severed from the other parts of the apparatus of respiration; and though rendered dead to the influence of the heart and lungs, were yet possessed of their other properties, such as sensibility and voluntary motion.

In the present paper it is proposed to prosecute this subject, by tracing the nerves which influence the motions of the trunk of the body in respiration, and to subject them to a similar enquiry.

It is an encouraging circumstance to the Author of this Paper, and may incline the Society to bear with the detail

into which it will be necessary to enter, that already practical benefits have arisen from the former paper; that the views presented there, as connected with general science, being carried into practice, have enabled the physician to make more accurate distinctions of disease, and the surgeon, in removing deformity, to avoid producing distortion.

Of the motions of the thorax, as affording a key to the intricacy of its nerves.

We have seen the necessity of considering all the functions and relations of a part of the animal machine, the nerves of which we propose to distinguish according to their uses; and this is even more necessary with respect to the thorax than the face. This will be evident, if we make a mere catalogue of the uses of this compages of bones and muscles. Besides affording support and protection to the heart and lungs, and the viscera of the higher region of the abdomen, the thorax performs these offices:

1. It alternately opposes and yields to the weight of the atmosphere, thus producing respiration.

2. In addition to the uniform motion of the chest in breathing, there is the occasional increase and agitation commensurate to the excited state of the animal frame, when additional muscles are brought into action.

3. There is the exertion of the respiratory apparatus in natural voice, and in articulate language.

4. Through the nerves and muscles employed in respiration, are also exhibited the emotions and passions of the mind.

5. The organs of the sense of smelling, and particularly the muscles which move the cartilages of the nose, are, in their exercise, as necessarily joined to the act of inspiration, as those of speech are to the act of expiration.

6. The powers of the arms in voluntary exertion, are in a great measure dependent upon the expansion of the thorax; so that the act of inspiration is always combined with sudden and powerful exertion. The more indeed we attend to the motions of the frame, whether in efforts of strength, or in the act of respiration, the more remarkable will the unexpected combinations of the muscles appear.

It is only when we are made sensible of the extent of the respiratory actions, and that they in effect extend over the whole face and neck and trunk, that we can comprehend how the mechanism of the thorax, or rather of the respiratory apparatus generally, affects the arrangement of the whole nervous system. Wherever, in examining the comparative anatomy of animals, we find ribs rising and falling by respiratory muscles, we have a *medulla spinalis*, and the distinction of *cerebrum* and *cerebellum*. And experiment and observation prove, that the seat of that power which controuls the extended act of respiration, is in the lateral portions of the *medulla oblongata*, from which it is continued through certain respiratory nerves which pass out from the neck, and also downwards, by corresponding columns of the spinal marrow, to the intercostal nerves.

Origins of the respiratory nerves.

The nerves on which the associated actions of respiration depend, and which have been proved to belong to this system, by

direct experiment, and the induction from anatomy, arise very nearly together. Their origins are not in a bundle, or fasciculus, but in a line or series, and from a distinct column of the spinal marrow. Behind the *corpus olivare*, and anterior to that process which descends from the cerebellum, the *corpus restiforme*, a convex strip of medullary matter, may be observed, and this convexity, or fasciculus, or *virga*, may be traced down the spinal marrow, betwixt the sulci, which give rise to the anterior and posterior roots of the spinal nerves.

This portion of medullary matter is narrow above where the *pons Varollii* overhangs it. It expands as it descends; opposite to the lower part of the *corpus olivare* it has reached its utmost convexity, after which it contracts a little, and is continued down the lateral part of the spinal marrow.

From this track of medullary matter on the side of the *medulla oblongata*, arise in succession from above downwards, the *portio dura* of the seventh nerve: the *glosso-pharyngeus* nerve: the nerve of the *par vagum*: the *nervus ad par vagum accessorius*: the *phrenic*, and the *external* respiratory nerves.

It is probable that the branches of the intercostal and lumbar nerves, which influence the intercostal muscles and the muscles of the abdomen in the act of respiration, are derived from the continuation of the same cord or slip of medullary matter. Nor will it escape observation, that the nerves called phrenic and external respiratory, though coming out with the cervical nerves, do, in all probability, take their origin from the same portion of the medulla spinalis with the accessory nerve.

The intercostal nerves, by their relations with the medulla oblongata, are equal to the performance of respiration, as it

regards the office of the lungs; but they are not adequate to those additional functions which are in a manner imposed upon the respiratory apparatus, when they are brought to combine in other offices.

Of the muscles of the trunk, which are brought in aid of the common respiratory muscles.

If we look upon the frame of the body for the purpose of determining which are the muscles best calculated to assist in the motions of the chest, when there is an increased or excited action, we shall have little difficulty in distinguishing them, and we shall have as little hesitation in assigning a use to the nerves which supply these muscles exclusively. For these nerves have the same origin: they take an intricate course, threading and passing betwixt other nerves and other muscles, to be entirely given to the muscles which heave the chest.

In this enquiry it is necessary to observe, that the life of animals is protected by a particular sense which gives rise to an instinctive motion of drawing the breath, and by which the chest is suddenly and powerfully expanded on exertion or alarm. The start on sudden alarm, is accompanied with a rapid expansion and rising of the chest, and the voice, at such a moment, is produced by suddenly inhaling, and not by expiration; and this expansion of the chest combines with the preparation for flight or defence, since the extension of the muscles lying on the breast and back is produced by this motion, and since they are thereby rendered more powerful in their influence upon the arms or anterior extremities. It cannot escape observation, that oppression and difficulty of

breathing is exhibited in gasping and forcible inspiration, in drawing the breath, not in throwing it out.

Accordingly, when we examine the trunk of the human body, we have no difficulty in distinguishing the muscles most capable of raising the chest; and these in effect, we see powerfully influenced in deep inspiration, whether the action be voluntary, as in speech, or involuntary, as in the last efforts of life, when sense is lost. They are the mastoid muscle, the trapezius, the serratus magnus, and the diaphragm.

1. *Sterno-cleido-mastoideus.** This muscle, by its attachment to the sternum or breast bone, raises or heaves the chest; and the operation of this muscle is very evident in all excited states of respiration, in speaking, and still more in singing, coughing, and sneezing. But there is something necessary to the full effect of this muscle on the chest, for otherwise it will be a muscle of the head, and not of the chest.

2. *The trapezius* † must fix the head or pull it backwards before the *mastoideus* can act as a respiratory muscle, and how they are combined we shall presently see. The position of the head of the asthmatic, during the fit, as well as the posture of the wounded or the dying, prove the influence of the upper part of the trapezius in excited respiration.

The trapezius has a still more powerful and important influence in respiration when the action rises above the ordinary condition, and that is by drawing back the scapula, to give the necessary effect to the action of the serratus magnus.

3. The *serratus magnus anticus* ‡ being extended over the whole side of the chest, and attached in all the extent from the second to the eighth rib, is very powerful in raising the

* See Plate XXXI. fig. 2, A. † Fig. 2, B. B. ‡ Fig. 2, E. E.

ribs; but it cannot exert this power, independently of the trapezius, since, without this combination, its force would be exerted in moving the scapula, and not the ribs; unless the scapula be fixed, or pulled back by the *trapezius*, the *serratus* is not a muscle of respiration.

In this manner do these three powerful muscles hang together in their action, combining with the diaphragm to enlarge the cavity of the chest in all its diameters.

The course of our enquiry leads us to ask, are these muscles privileged above others by any peculiarity of nerves? And the answer is plain: to these muscles alone, are the nerves, which I am about to call respiratory nerves of the chest, distributed.

*Anatomy of the respiratory nerves of the trunk.**

The nerves which give rise to the extraordinary intricacy of this system on the side of the neck, are the spinal accessory nerve, the phrenic nerve, and the external thoracic nerve. By reference to any common book of anatomy, the phrenic nerve (4 Fig. 2.) will be found to have its great root or origin from the fourth cervical nerve; and there joins this, a more slender branch from the third cervical nerve. But, besides these roots, it has connections, which of themselves would mark the relations of the nerve; high in the neck, it is connected with the *nervus vagus* and with the *lingualis medius*, while, at the same time, a branch is given off to the muscles of the larynx. The trunk of the nerve descends into the cavity of the thorax, and gives no branches until arriving at the diaphragm (Fig. 2.G), it sends out numerous diverging branches, which are lost in the substance of that muscle.

* See Plate XXXI. Fig. 1 and 2.

It has been long known that irritation of this nerve convulses the diaphragm, and that cutting it across paralyses that muscle. These facts, with the consideration of its course, prove it to be a respiratory nerve, and such has been the universal opinion.

But to what purpose should a distinct nerve be sent to the diaphragm, if the other muscles, seated externally, and which are associated in action with the diaphragm, and as important to respiration, were left without a similar tie to unite them with each other, and with the organs of the voice?

The external respiratory nerve of the thorax (5 Fig. II.) is a counterpart of the internal or phrenic nerve. It comes out from the 4th and 5th cervical nerves, and often it is connected with the phrenic. It diverges somewhat from that nerve, because, instead of descending within the chest, it falls over the ribs, and descends in a distinct flat trunk upon the outside of the chest, to be distributed intirely to the *serratus magnus anticus*. This muscle has nerves from the spinal marrow, because it has to combine in the motions of the frame in loco-motion. But the long descending nerve is a respiratory nerve; which we may know from its origin, course, and destination; in its origin and course it is like the diaphragmatic nerve, and in its destination also, since it is given to a muscle necessary to full inspiration.

I come now to the *spinal accessory nerve* (Plate XXXI. fig. II. 3)* which is more particularly an object in this paper. It is called here the superior respiratory nerve of the trunk. Experiments may take a colour from the preconceived idea, but the accurate investigation of the structure will not deceive

* *Nervus ad par vagum accessorius.*

us. The author therefore entreats attention to the anatomy of this nerve, as leading in the most conclusive manner to a knowledge of its functions.

It arises from the cervical portion of the spinal marrow (Plate XXXI. fig. I. 4); but instead of collecting its branches to go out by the side of the vertebræ, like the internal and external respiratory nerves, it shoots upwards through the theca of the spinal marrow, enters the skull, and joins the 8th pair of nerves; from which it has its term of accessory. We see the roots of this nerve as far down as the 4th cervical nerve.* These roots arise neither from the posterior nor the anterior column of the spinal marrow, but betwixt the posterior roots of the cervical nerves and the *ligamentum denticulatum*, and from the *column of medullary matter* above described. The origins of this nerve come off in one line, and that line is in the direction of the roots of the eighth pair, and of that nerve which has been proved to be the respiratory nerve of the face. In its ascent the accessory nerve is attached to the posterior root of the first cervical nerve.

The nerve having ascended through the *foramen magnum*, passes out from the skull associated with the nerves constituting the *eighth pair*, and in the same sheath with them; they all go out through the *foramen lacerum*, and by the side of the jugular vein. In this course the accessory nerve divides into two. One of these divisions joins filaments of the *par vagum* (Fig. II. 6); and these again send nerves to the *glosso-pharyngeal* nerve (Fig. II. 2); and sometimes a branch may be seen going to the *lingualis medius*. The

* In the ass, its roots are seen to extend much lower down.

more exterior division of the accessory nerve descends behind the jugular vein, and comes forward and perforates the mastoid muscle, (Plate XXXI. fig. II. A). In its passage through the muscle it sends off branches which course through its substance; and if, as sometimes happens, though rarely, the nerve does not pass through the muscle, these branches are, notwithstanding, invariably given to it.

When the nerve has escaped from the back part of the mastoid muscle, it forms a communication with that branch of the 3d cervical nerve that ascends behind the muscle; and nearly at the same time it is joined by a branch from the 2d cervical nerve. The superior respiratory nerve now descends upon the neck, and begins to disperse its branches in regular order to the edge of the trapezius muscle; (Fig. II. B.) four or five branches take their course to that muscle, separate into minute subdivisions, and are lost in its substance. One more considerable division, being the lowest of these, is joined by a long descending branch of the 2d cervical nerve. Encreased by this addition, it descends under the trapezius and behind the clavicle. Following this descending branch, it will be found exclusively attached to the trapezius. Behind the scapula it is again joined by branches from the spinal nerves; and here a sort of imperfect plexus is formed, from which divisions of the nerve, still descending, follow the lower edge of the muscle, and are finally dispersed among its fibres.

This nerve arises from the same column with the respiratory nerves; it takes a most intricate and circuitous passage to form a junction with nerves which we know to belong to that class; it sends branches to join the nerves of the tongue

and pharynx; it sends branches to the larynx in company with the branches of the *par vagum;* it then crosses the great nerves of the neck, passes under the spinal nerves, goes to no other muscles in its course, but lavishes all its branches on the mastoid and trapezius muscles. To an anatomist it is as plainly set forth as if it were written in our mother tongue, this is *the superior respiratory nerve of the trunk.**

Comparative view of these nerves.

If we examine the *par vagum*, the *portio dura* of the face, the *external thoracic*, the *diaphragmatic*, and the *spinal accessory* nerves, by comparative anatomy, we shall conclude that they are all respiratory nerves, by their accommodating themselves to the form and play of the organs of respiration. In fishes, the respiratory nerve† goes out from the back part of the *medulla oblongata*. When it escapes from the skull it becomes remarkably enlarged, and then disperses its branches to the branchiæ and the stomach. But from the same nerve go off branches to the muscles moving the gills and operculum, whilst a division of the nerve is prolonged under the lateral line of the body to the tail. It is said, this division sends off no branches, but this is not correct; it gives branches in regular succession to the muscles from the shoulder to the tail. Experiments have been made upon these nerves, but their detail would lead us too far. It is scarcely necessary to add, that there is neither phrenic nor spinal accessory, nor

* *Lobstein*, in a dissertation on this nerve, finding the difficulty of accounting for the *nervous fluid* coming by a double passage to the muscle, concludes, *veniet forsan tempus quo istæ quæ nunc latent, dies extrahat et longioris aevi diligentia.*

† The nerve which by its subdivision supplies the heart, lungs, and stomach, and the muscles of the gills.

external thoracic nerves in fishes, the order of their muscular system not requiring them. In birds, the structure of the wing, and the absence of the mastoid muscle, render the spinal accessory nerve unnecessary; it is wanting for the reason that in the absence of the diaphragm there is no phrenic nerve. Quadrupeds have the three respiratory nerves of the trunk; but even in them there are variations in the muscular frame, which illustrate the appropriation of the nerves. The construction of the neck of the camel is like that of birds; there is a succession of short muscles along the side of the neck, and attached to the vertebræ; but there is no long muscle, like the *sterno-cleido-mastoideus*, contributing to the motion of respiration. There is, accordingly, no spinal accessory nerve in the neck of this animal.

We have a remarkable example of the manner in which these nerves vary in their course of distribution, and yet retain their appropriate functions, in the nerves of the neck of birds. In them, the bill precludes the necessity of the portio dura going forward to the nostrils and lips; the nerve turns backwards, and is given to the neck and throat; and it is particularly worthy of remark, that the action of raising the feathers of the neck, as when the game cock is facing his opponent, is taken away by the division of this nerve.

The functions of these nerves farther illustrated.

Before having recourse to experiments on brutes, we may observe what takes place in our own bodies By placing the hand upon the neck, we may be sensible that the mastoid muscle has two motions. The lower extremity of the muscle is fixed when we move the head; but when we use the muscle

in inspiration, the head, and consequently the upper extremity of the muscle, are fixed. Now, if we endeavour to raise the sternum through the operation of this muscle, we shall find that other muscles are, insensibly to us, brought into action, which have nothing to do with this raising of the sternum. For example; if we strain to raise the lower extremity of the muscle, we shall unavoidably produce an action of the muscles of the nostrils; by which association of actions, we shall discover, that we are using the *mastoideus* as a respiratory muscle. If we reverse the action, and move the upper extremity of the muscle, other muscles will be drawn into co-operation, but they will be such as assist in the motion given to the head. Or we may vary the operation in another way. In snuffing or smelling, if we place the fingers on the portions of the mastoid muscles which are attached to the sternum, we shall find every little motion of the nostrils accompanied with corresponding actions of the sternal portions of the muscles in the neck.

A man having a complete hemiplegia, the side of his face relaxed, the arm hanging down powerless, and the leg dragged in walking, we were curious to know if the influence pervaded all the nerves of the side, or only the regular or voluntary nerves. Some trouble was taken to make him heave up the shoulder of the debilitated side, but to no purpose. He could only do it by bending the spine to the other side, and as it were weighing up the paralytic shoulder. But on setting him fairly in front, and asking him to make a full inspiration, both shoulders were elevated at the same time that both the nostrils were in motion. The respiratory nerve of the face, and the superior respiratory nerve, were entire

in their office; and, although the regular system of nerves refused acting, the *sterno-mastoideus* and the *trapezius* partook of their share in the act of respiration. Seeing that the mastoid muscle has two sets of nerves, that one of these is of the class of voluntary nerves, and the other of respiratory nerves, are we not borne out in concluding, that when the head is moved, being a voluntary act strictly, it is performed through the common class of voluntary nerves? that when the chest is raised, it is an act of respiration, and is affected through those nerves which controul the muscles in respiration?

This conclusion is confirmed by the following experiment. In the ass, there are two muscles which take the office of the mastoid muscle; one is inserted into the jaw, which we may call *sterno-maxillaris*, and the other into the vertebræ, viz. *sterno-vertebralis*. To these the superior respiratory nerve (or spinal accessory) is distributed in its passage to the trapezius. These muscles are at the same time supplied with numerous nerves directly from the spinal marrow. If we expose the superior respiratory nerve, and then induce excited respiration, so as to bring these muscles into powerful action in combination with the other muscles of respiration, and if, while this action is performed, we divide the nerve, the motion ceases, and the muscle remains relaxed until the animal brings it into action as a voluntary muscle.

An ass being thrown, its phrenic nerves were divided, on which a remarkable heaving of the chest took place. It rose higher, and the margins of the chest were more expanded at each inspiration. There was no particular excitement of the muscles of the neck, shoulder, or throat, at this time; so

that to excite the actions of these muscles, it was necessary to compress the nostrils. When they began to act with more violence, keeping time with the actions of the other muscles of respiration, the superior respiratory nerve was divided; immediately the action ceased in the muscles attached to the sternum of the side where the nerve was divided, while the corresponding muscles of the other side continued their actions.

After dividing the spinal marrow between the vertebræ of the neck and those of the back, respiration is continued by the diaphragm: which experiment, as it is often mentioned by physiologists, the author has not thought it necessary to repeat, but only to institute the following experiment on an ass. The phrenic nerves being first divided, and then the spinal marrow cut across at the bottom of the cervical vertebræ, respiration was stopt in the chest; but there continued a catching and strong action at regular intervals in the muscles of the nostrils, face, and side of the neck. The main part of the apparatus of respiration was stopped, but these accessory muscles remained animated, and making ineffectual endeavours to perform the respiration. When apparent death had taken place, the ass was re-animated by artificial breathing, and then these muscles on the face and neck were restored to activity, and became subject to regular and successive contractions, as in excited respiration, whilst the chest remained at rest. These actions continued for a short time, and then ceased; but upon artificial respiration being again produced, the same results followed. This was repeated several times, the animal remaining insensible during these experiments.

Upon stimulating the nerves after the death of this animal, it was observed, that the class of respiratory nerves retained their power of exciting their respective muscles into action, long after the other nerves had ceased to exert any power; they were evidently of that class which retain their life the longest.

It is a duty to avoid the unnecessary repetition of experiments, and I have now to make a short statement of facts, resting on the highest authorities: experiments made without reference to the views now presented to the Society.

The division of the recurrent branch of the *par vagum* destroys the voice.*

The division of the laryngeal branch of the *par vagum* stops the consent of motion between the muscles of the *glottis* and the muscles of the chest.†

The injury or compression of the *par vagum* produces difficulty of breathing.‡

By the assistance of these well known facts, we complete the knowledge of the circle of actions which result from the respiratory nerves.

The *medulla oblongata* and *spinalis* are composed of columns of nervous matter, which (from the different powers of the nerves, as they arise from the one or other of these columns), possess distinct properties. In animals that breathe by ribs and a numerous class of muscles, and which animals have a spinal marrow, we see that a column of nervous

* Sectis ambobus nervis recurrentibus vox perit: *Arnemann, Sömmerring, Morgagni.*

† *Le Gallois.*

‡ Vinculo compressis nervis vagis oriuntur in bestiis spirandi difficultas, surditas, vomitus, corruptio ciborum in ventriculo. *Sömmerring, Haller, Brun de ligaturis nervorum.*

matter is embraced between the anterior and posterior *virgæ* of that body, and that this portion may be traced downwards between the roots of the spinal nerves. From the upper part of this column, where it begins in the *medulla oblongata*, the several nerves proceed which have formed the subject of these papers, and on the influence of which, it has been proved, the motions of respiration principally depend. It is not an extravagant conclusion to say farther, that the power of the regular succession of intercostal and lumbar nerves, as far as they regulate the respiratory actions, proceeds from the connections of the roots of these nerves with this column, which is continued downwards, and which can throughout be distinguished from the rest of the spinal marrow.

We are now enabled to distinguish the influence of the spinal marrow and its regular succession of nerves, from those which have been traced in these papers. The first are essential to the act of respiration; without them the others are unequal to the task. But on the other hand, although the regular succession of spinal nerves be equal to the raising and depressing the thorax, they are not competent to the performance of the motions of the glottis, pharynx, lips, and nostrils, which several parts are necessarily influenced in excited respiration, as well as in the acts of smelling, coughing, sneezing, and speaking: for these, the co-operation of the whole extended class of respiratory nerves is required.

Surveying the complicated machinery which in man is prepared for these various offices, we may reap the benefit of these fatiguing details, in the contemplation of the most interesting phenomena in nature. The relations of the subject

may be presented under the heads of pathology, and expression.

Of pathology, as illustrated by a knowledge of the respiratory system of nerves.

When we survey the full extent of the respiratory system of nerves, we are prepared to comprehend its importance to the continuance of life. The infant born without a brain can breathe if the origins of these nerves be entire. Deep wounds of the brain, though eventually fatal, are not necessarily, or instantly so. The man wounded in the spine below the origins of the nerves which we have traced, drags on existence for a time; but a bruise on the part of the *medulla oblongata*, from which these nerves take their departure, is death in the instant; a breath is not drawn again.

In describing the effects of violence on the medulla oblongata, authors have attributed the sudden death to injury of the roots of the nerves of the par vagum; and yet we have a statement from the same authority, that an animal will survive the division of both nerves of the par vagum. Now that we find that many respiratory nerves depart from the same centre, and go out to all the parts of the muscular frame, which move in respiration, we can better comprehend, how injury of the medulla oblongata suppresses at once the act of respiration in the nostrils, throat, and windpipe, and the action of the muscles both without and within the chest; even the expression of the agony of dying is, by the injury of the roots of all these nerves, suddenly interrupted, and actual death follows quickly, owing to the cessation of the respiratory functions.

A young man was brought into the Middlesex Hospital, who had fallen upon his head. He soon recovered, and lay for some time in the hospital without exhibiting a symptom to raise alarm. He had given thanks to the assembled Governors of the Hospital, and had returned into the ward for his bundle, when, on turning round to bid adieu to the other patients, he fell, and in the instant expired. Upon examining his head, it was found that the margins of the occipital hole had been broken: no doubt it had happened that in turning his head the pieces were displaced, and closed and crushed the medulla oblongata, as it passes from the skull.

A man was trundling a wheel-barrow in Goodge Street, which is immediately adjoining the Middlesex Hospital: in going from the carriage-way to the flag-stones he met the impediment of the curb-stone. He made several efforts to overcome it, and at length drawing back the wheelbarrow, he made a push, and succeeded; but the wheel running forward, he fell, and remained motionless. He was taken into the Hospital, but he was found to be quite dead. The tooth-like process of the second vertebra of the neck had burst from the transverse ligament of the first.* The impulse given to the head had done this violence, and had at the same time carried forward the spinal marrow against the process, and on which it was crushed.

We have seen by experiments, that the respiratory nerves are distinguished from the other nerves by retaining their power longer: that they are alive to impression, and can be

* In my collection there is a preparation which exhibits this ligament destroyed by disease. The death was sudden, and caused by the falling forward of the head, and the crushing of the medulla spinalis.

made to produce convulsions in the muscles they supply, after the other nerves are dead to the application of stimuli. In disease, during the oppression of the mental faculties, and on the approach of death, we witness these nerves, and the muscles put into operation by them, continuing their functions, when in other respects the body is dead. This circumstance, so familiar to the medical observer, might have led to the conclusion to which we have arrived, more laboriously, through anatomical investigations: that there are a great many muscles extended over the body, and which perform the common offices under the will, which are occasionally drawn into combination with the muscles of respiration, and are held in relation to the vital functions by a distinct system of nerves, and that these nerves have a centre and a source of power, different from that of the voluntary nerves.

These nerves, so peculiar in relation and function, are differently influenced by disease from the other division of the nervous system. Their functions are left entire when the voluntary nerves have ceased to act, and they are sometimes strangely disordered, while the mind is entire in all its offices, and the voluntary operations perfect. In tetanus the voluntary nerves are under influence, and the voluntary motions locked up in convulsions; in hydrophobia the respiratory system is affected; and hence the convulsions of the throat, the paroxysms of suffocation, the speechless agony, and the excess of expression in the whole frame, while the voluntary motions are free.

The confusion between vital and voluntary nerves, the combining the par vagum and sympathetic nerves together, and the exclusion of the *portio dura* of the 7th nerve, the spinal accessory nerve, and the external thoracic nerve, from their

natural classification with the diaphragmatic or phrenic, has given rise to very vague theories, and occasioned very inaccurate statements of pathological facts. What remains to be said under this head, I would rather offer in the form of queries.

The frequency of sudden death, where no corresponding appearances are exhibited in the brain or heart, leads us to consider more attentively the only part of the system through which life can be directly extinguished. In *angina pectoris*, we witness the agony of suffering in this system when the patient survives; and when he dies suddenly, we can imagine it to proceed from an influence extending over these nerves, and interrupting the vital operations. We have seen that a branch of this system may suddenly cease to operate on the corresponding muscles, and that in this way the side of the face may be deprived of all participation in the act of respiration, and all expression be lost. What would result from a more universal defect in the actions of this class of nerves, but sudden death?

Could we expect that the diseases of lethargy and somnolency, should be distinctly divided from apoplexies, while the organs on which the distinction of symptoms principally depend, were imperfectly understood?

The stomach, supplied with the great central nerve of this system, exhibits the most powerful influence on these extended nerves; a blow on the stomach "doubles up" the bruiser, and occasions that gasping and crowing which sufficiently indicates the course of the injury; a little more severe, and the blow is instantly fatal.

The position of the asthmatic, shows how this system is

affected; whether directly or indirectly, it is not our present business to enquire. He stands stooping forward, resting his arms so as to throw the muscles of the chest into operation upon the ribs. The position of the head and the rigidity of the muscles of the neck, the action of the mastoid muscle, and of the cutaneous muscle, visible in the retraction of the cheeks and mouth, and the inflation of the nostrils, carry us back in review of the nerves and muscles of respiration.

It will now perhaps be acknowledged, that the methods of physiologists, in accounting for the combination of parts in the actions of respiration, were very imperfect, or rather altogether erroneous. To account for the convulsion of the diaphragm in sneezing, they were constrained to go a far way about: first, connecting the roots of the phrenic with the sympathetic nerve: bestowing sensibility on the latter, which it does not possess: then, following a remote connection between it and the nerves of the nose; then again, counting the relations between the facial nerve and the 3rd of the neck: they satisfied themselves that they had explained the manner in which the diaphragm became convulsed upon irritating the membrane of the nose. Another misconception was engrafted on the first; they spoke of these actions as convulsive and irregular, which are amongst the most admirable provisions for the protection of life. As to the act of sneezing, like coughing, it is a consequence of an irritation of the extremity of one of the respiratory nerves, whence the whole muscles of respiration are brought into action. That there is nothing accidental, nor of the nature of convulsion, is shown, by the admirable adjustment of the muscles to the object. A body irritating the glottis, will call into simultaneous action the

muscles of respiration, so as to throw out the air with a force capable of removing the offending body. But if the irritation be on the membrane of the nose, the stream of air is directed differently, and, by the action of sneezing, the irritating particles are removed from these surfaces. By the consideration of how many little muscles require adjustment to produce this change in the direction of the stream of air, we may know, that the action is instinctive, ordered with the utmost accuracy, and very different from convulsion.

We may notice another office of these nerves; in smiling, laughing, and weeping, the influence is solely propagated through them. The face we have seen is dead to all changes of the kind when the nerve of this class which goes to it is destroyed, whether it be by division of the nerve, or from its being surrounded with inflammation or suppuration. When we consider that all the respiratory nerves depart from the same source, and participate in the same functions; and more especially when we see the respiratory organs so very distinctly affected in the conditions of the mind, which give rise to these affections, it is not too much to suppose, that what is proved in regard to one of these nerves, is true of the whole class, and that they alone are influenced in laughter. Physiologists who have not investigated the cause, are yet agreed in describing laughter to be a condition of the respiratory muscles, where the air is drawn in rapidly, and thrown out in short spasmodic motions of these muscles; that crying is nearly the reverse, the inspiration being cut by spasmodic actions of the muscles of inspiration. By these considerations are explained the *subrisus* which arises from abdominal irritation, and the sardonic retraction of the muscles of the face produced by

wounds of vital parts, and particularly of the diaphragm. It explains also the successive convulsive lifting of the shoulders in wounds of the diaphragm.

That a system of nerves so intimately combined as this is with the other parts of the general system, should suffer in hysterical disorders, cannot surprise us; and admitting that irritation reaches to the respiratory system, we may perceive how rapidly the change may be produced, from the convulsions of laughter to those of crying; and where, if there be a corresponding condition of the mind, it rather follows than precedes the expression of the frame.

These respiratory nerves are organs of expression.

It would have been extraordinary if we had arrived at any satisfactory theory of expression, before it was known through what instruments the mind influenced the body, during emotion or passion. But since we know that the division of the respiratory nerve of the face, deprives an animal of all expression; and that the expressive smile of the human face is lost by an injury of this nerve: since it is equally apparent, that the convulsions of laughter arise from an influence extended over this class of nerves; it comes to be in some sort a duty in pursuing this matter, to examine farther into the subject of expression. We may be at the same time assured of this, that whatever serves to explain the constant and natural operations of the frame, will also exhibit to us the symptoms of disease with more precision.

In terror, we can readily conceive, why a man stands with eyes intently fixed on the object of his fears: the eyebrows elevated, and the eye balls largely uncovered; or why,

with hesitating and bewildered steps, his eyes are rapidly and wildly in search of something. In this we only perceive the intent application of his mind to the objects of his apprehensions, and its direct influence on the outward organs. But when we observe him farther, there is a spasm on his breast: he cannot breathe freely: the chest remains elevated, and his respiration is short and rapid: there is a gasping and convulsive motion of his lips: a tremor on his hollow cheeks: a gulping and catching of his throat: his heart knocks at his ribs, while yet there is no force in the circulation, the lips and cheeks being ashy pale.

It is obvious that there is here a reflected influence in operation. The language and sentiments of every people have pointed to the heart, as the seat of passion, and every individual must have felt its truth. For though the heart be not in the proper sense the seat of passion, it is influenced by the conditions of the mind, and from thence its influence is extended through the respiratory organs, so as to mount to the throat, and lips, and cheeks, and account for every movement in passion, which is not explained by the direct influence of the mind upon the features.

So we shall find, if we attend to the expression of grief, that the same phenomena are presented; and we may catalogue them, as it were, anatomically. Imagine the overwhelming influence of grief—the object in the mind has absorbed the powers of the frame; the body is no more regarded, the spirits have left it; it reclines, and the limbs gravitate, the whole body is nerveless and relaxed, and the person scarcely breathes; so far there is no difficulty in comprehending the effect in the cause. But why, at intervals, is

there a long drawn sigh, why are the neck and throat convulsed, and whence the quivering and swelling of the lip, why the deadly paleness, and the surface earthy cold; or why does convulsion spread over the frame like a paroxysm of suffocation?

To those I address, it is unnecessary to go farther, than to indicate that the nerves treated of in these papers, are the instruments of expression, from the smile upon the infant's cheek to the last agony of life. It is when the strong man is subdued by this mysterious influence of soul on body, and when the passions may be truly said to tear the breast, that we have the most afflicting picture of human frailty, and the most unequivocal proof, that it is the order of functions which we have been considering that is then affected. In the first struggles of the infant to draw breath, in the man recovering from a state of suffocation, and in the agony of passion, when the breast labours from the influence at the heart, the same system of parts is affected, the same nerves, the same muscles, and the symptoms or characters have a strict resemblance.

Having examined the system of nerves and muscles, which are the agents in respiration, in their fullest extent and in all their bearings; having looked at them, in their highest state of complication in the human body, and having traced them upwards, from the animals of simple structure, and then by experiment, and in a manner analytically as well as synthetically, their relations become obvious. Instead of one respiratory nerve, the *par vagum*, the nerve so called, is found to be the central one of a system of nerves of great extent.

Instead of the relations of the vital organs of circulation and respiration depending on some supposed influence of the sympathetic nerve, they are found to have an appropriate system.

This system of nerves, extricated from the seeming confusion in which it lay hitherto encumbered, is found to be superadded to that of mere feeling and agency, attributes common to all animals: through it we see, engrafted as it were, and superadded to the original nature, higher powers of agency, corresponding to our condition of mental superiority: these are not the organs of breathing merely, but of natural and articulate language also, and adapted to the expression of sentiment, in the workings of the countenance and of the breast, that is by signs, as well as by words. So that the breast becomes the organ of the passions, and bears the same relation to the developement of sentiments, as the organs of the senses do to the ideas of sense.

EXPLANATION OF PLATE XXXI.

Fig. 1. Represents the *medulla spinalis.*

A. The *pons Varolii.*

B. B. The anterior medullary columns of the spinal marrow, continued from the *corpora pyramidalia.*

C. *Corpus olivare.*

D. *Corpus restiforme.*

1. The origin of the respiratory nerve of the face.
2. Origin of the glosso-pharyngeal nerve.
3. Origin of the nerve of the par vagum.
4. Origin of the spinal accessory nerve, or superior respiratory nerve of the trunk.

Fig. 2. Plan of the respiratory nerves in their course through the body.

A. *The sterno-cleido-mastoideus muscle.*

B. B. The *trapezius* muscle. It is seen to arise from the back of the head, and from the spine; it is inserted into

C. The scapula, and

D. The clavicle.

E. E. The *serratus magnus anticus.* It is left at its attachment to the ribs, but cut off from its insertion into the scapula, so as to expose the trapezius and the spinal accessory nerve.

F. The lower surface of the diaphragm.

G. The upper surface of the diaphragm.

H. The larynx.

The four great muscles (A. B.B. E.E. F. G.) are associated together, and joined to the organs of the voice, and of smelling, &c. by the nerves displayed here.

To simplify this view, the regular or symmetrical system of nerves is not presented in this drawing, but only the respiratory nerves. It is the entwining of nerves of distinct systems which produces the apparent intricacy. If the spinal nerves were represented crossing these, and the network of the sympathetic superadded to them, we should have all the seeming confusion of the dissected body.

1. Respiratory nerve of the face, or portio dura of authors.
2. The glosso-pharyngeal nerve.
3. The superior respiratory nerve. It is seen to pass through the sterno-cleido-mastoideus muscle, and to supply it with branches: then to take a course

down the side of the neck, branching exclusively to the trapezius muscle.

4. The phrenic or diaphragmatic nerve. It is seen coming out from the spine, and running a direct course to the diaphragm.

5. The external respiratory nerve of the chest. It is like the last nerve in its origin, but it deviates in its course, passes on the outside of the chest to supply the powerful respiratory muscle, the serratus magnus E. E.

These three nerves combine the mastoid and the trapezius muscles, the serratus magnus and the diaphragm, with the larynx, the tongue, and nostrils.

6. 7. The nerve of the par vagum. Coming from the same origin with the other respiratory nerves, it passes down to the internal organs; but in its passage gives off these:

8. The superior laryngeal nerve, a branch of the last nerve.

9. The recurrent nerve; a branch also of the nerve of the par vagum. Where the nerve of the par vagum is in the thorax (7) at the same time that it sends off the recurrent (9), it sends off many small nerves to the heart and the lungs, and then descends in a plexus on the œsophagus, to the stomach.

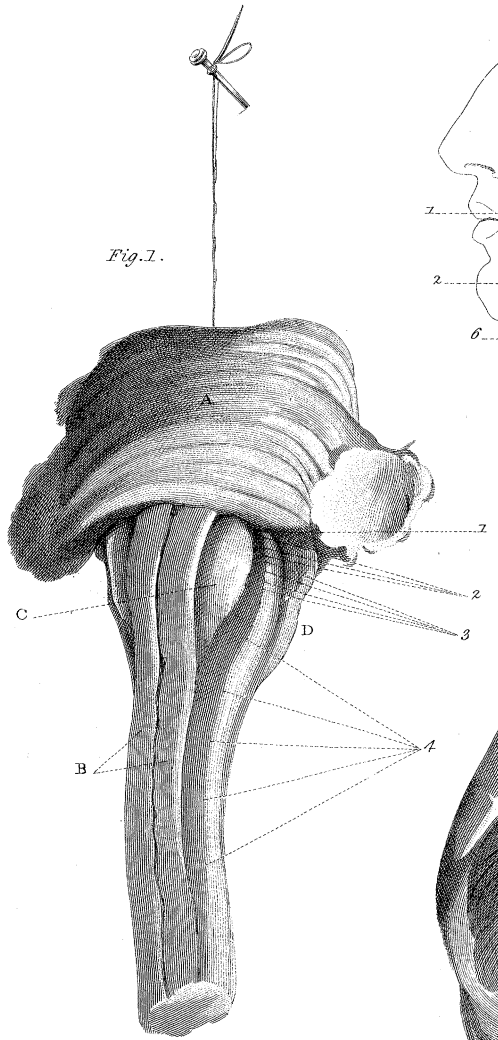

Fig. 1.

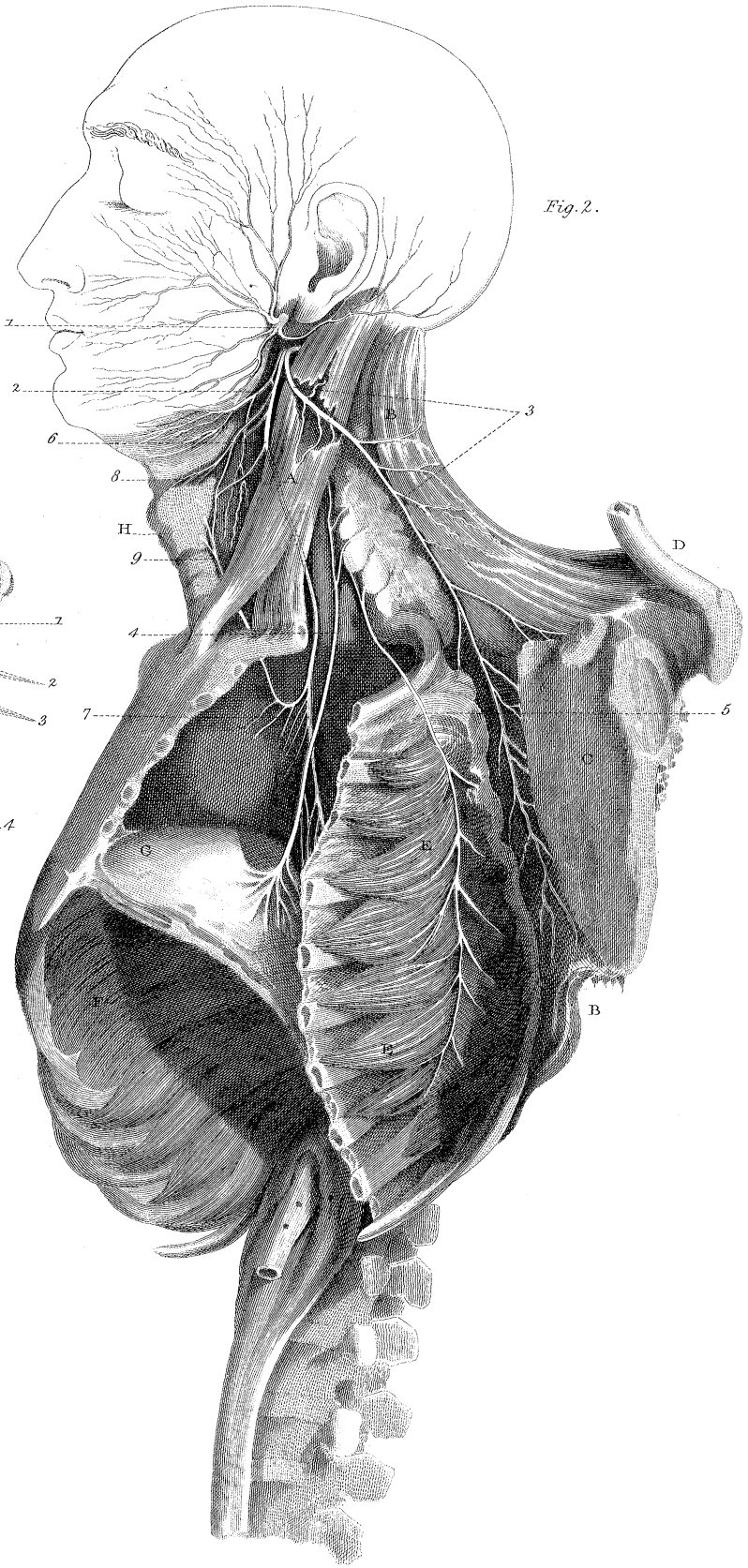

Fig. 2.