XXVIII. *On the Nerves; giving an account of some experiments on their structure and functions, which lead to a new arrangement of the system.* *By* CHARLES BELL, *Esq.* *Communicated by Sir* HUMPHRY DAVY, *Bart. P. R. S.*

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DURING the general advancement of science which has lately taken place in this country, observations have been gradually accumulating in the schools of the metropolis, which prove that the department of Anatomy has not been stationary. The nervous system, hitherto the most unsatisfactory part of a physiologist's studies, has assumed a new character. The intricacies of that system have been unravelled, and the peculiar structure and functions of the individual nerves ascertained; so that the absolute confusion in which this department was involved has disappeared, and the natural and simple order has been discovered.

In proceeding to give some account of these new observations, the Author of this paper had conceived, that it would be more suitable to the scientific body he had to address, to lay the subject before them in the precise manner in which it first presented itself to his enquiries, and to detail his observations and experiments in the succession in which they were made; but he has been persuaded by some of the Members of this Society to change that form, and to present the subject in the manner to which he has been

accustomed, in teaching these doctrines; and they were pleased to say, that in this way, a new subject would be more readily comprehended.

Intricacy of the nervous system.

Anatomists have of late, not only in this country, but also in Germany and Italy, made great improvement in the minute dissection and display of the nerves; but whilst the doctrines hitherto received prevail, the discovery of new branches of nerves, and new ganglia, only involve the subject in deeper obscurity. Whilst the nerves are supposed to proceed from one great centre, to have the same structure and functions, and to be all sensible, and all of them to convey what has been vaguely called nervous power, these discoveries of new nerves and ganglia are worse than useless; they increase the intricacy, and repel enquiry. The endless confusion of the subject induces the physician, instead of taking the nervous system as the secure ground of his practice, to dismiss it from his course of study, as a subject presenting too great irregularity for legitimate investigation or reliance.

When the physiologist sees two distinct nerves spreading their branches to every part of the face, (as in Pl. XXX.) three nerves from different sources given to the tongue, four to the throat, and nerves in most perplexing intricacy to the neck; when he finds one nerve with numerous ganglia or knots upon it, and another without them; when, in short, after a minute dissection of the nervous system, he finds a mesh, or network, spreading everywhere, it is not surprising that the seeming intricacy and confusion should make him, in despair, resign enquiry. But the Author of this paper being forced, in the

course of his duty, to go minutely over the demonstration of the nerves, year after year, without allowing himself to resign the subject merely on account of its intricacy, and finding the facts which he had to explain in his demonstrations of the anatomy, quite inconsistent with the received opinions, he gradually, after much study, was enabled to decypher and to read that language, of which the character had hitherto been imperfectly known; and now even the youngest students are brought to comprehend so much of the subject, that the idea of chance, or accident, or real confusion among these numerous branches, is entirely dismissed; and what remains unexplained has, by the success of our past enquiries, become a subject of peculiar interest, from the conviction, that attention to the minute anatomy, under the guidance of cautious and fair induction, will sooner or later lead to a comprehension of the whole system.

Statement of the object of the paper.

The Author means to limit his present enquiry to *the nerves of respiration*. But according to his conception of this matter, these nerves form a system of great extent, comprehending *all the nerves which serve to combine the muscles employed in the act of breathing and speaking*.

The first point of enquiry naturally is, how many of the muscles are combined in the act of respiration? and the second question, by what means are these muscles, which are seated apart from each other, and many of them capable of performing distinct offices, combined together in respiration? It may sound oddly to speak of the respiratory nerve of the face, of the neck, and of the shoulder; and it may be neces-

sary to give an illustration of the sense in which the term is intended to be employed. When a post-horse has run its stage, and the circulation is hurried and the respiration excited, what is his condition? Does he breathe with his ribs only; with the muscles which raise and depress the chest? No. The flanks are in violent action; the neck as well as the chest is in powerful excitement; the nostrils as well as the throat keep time with the motion of the chest. So if a man be excited by exercise or passion, or by whatever accelerates the pulse, the respiratory action is extended and encreased; and, instead of the gentle and scarcely perceptible motion of the chest, as in common breathing, the shoulders are raised at each inspiration, the muscles of the throat and neck are violently drawn, and the lips and nostrils move in time with the general action; and if he does not breathe through the mouth, the nostrils expand, and fall in time with the rising and falling of the chest; and that apparatus of cartilages and muscles of the nose (which are as curious as the mechanism of the chest, and which are for expanding these air tubes) are as regularly in action as the levator and depressor muscles of the ribs.

It is quite obvious, that some hundred muscles thus employed in the act of breathing, or in the common actions of coughing, sneezing, speaking, and singing, cannot be associated without cords of connection or affinity, which combine them in the performance of these actions: the nerves which serve this purpose I call respiratory nerves.

The nerves of the animal frame are complex, in proportion to the variety of functions which the parts have to maintain.

When we minutely and carefully examine the nerves of the human body, and compare them with those of other animals, a very singular coincidence is observed between the number of organs, the compound nature of their functions, and the number of nerves which are transmitted to them. No organ which possesses only one property, or endowment, has more than one nerve, however exquisite the sense or action may be; but if two nerves, coming from different sources, are directed to one part, this is the sign of a double function performed by it. If a part, or organ, have many distinct nerves, we may be certain that, instead of having a mere accumulation of nervous power, it possesses distinct powers, or enters into different combinations, in proportion to the number of its nerves. The knowledge of this circumstance gives new interest to the investigation of this part of anatomy.

Thus, in reviewing the comparative anatomy of the nerves of the mouth, we shall find, that in creatures which do not breathe, the mouth having only one function to perform, one nerve is sufficient. In certain animals where the face and nostrils have no complexity of relations, these parts have only a single nerve. If the throat has no complexity of organization, it has no variety of nerves. But on the other hand, when the anatomist employs weeks to dissect and disentangle the nerves of the tongue, throat, and palate, in the human subject, he finds at length, that he has exhibited the branches of five different trunks of nerves; and there is no clue to the labyrinth, until he considers the multiplied offices of the mouth

in man; that it is a pneumatic as much as a manducatory organ; that it is the organ of the voice and of speech, as of taste and exquisite feeling. It would indeed be matter of surprise, if the same nerve served for the action of gnawing and feeding in the lower animals of simple structure, and also for the governance of those complicated operations, which serve to interpret the wants and sentiments of man.

Such are the views which naturally arise from an acquaintance with the nerves of the human body; but a comparison of them, with those of the lower classes of animals, enables us to establish a more lucid order, and that not in an arbitrary manner, but perfectly according to nature.

The nerves of all creatures may be divided into two parts, or systems; the one simple and uniform, the other irregular and complex, in proportion to the complexity of organization.

When the nerves of the face, mouth, throat, and neck of the human subject are minutely displayed, it seems impracticable to reduce the numerous nerves which cross and entwine with each other to two distinct classes; yet nothing is more certain than that this may be done, and by an easy and natural method.

The principle which is to guide us, is obtained by ascertaining what parts of the organization of an animal are necessary to life and motion; what organs are superadded as the animal advances in the scale of existence, as necessary to higher and more complex enjoyments and actions.

Where an animal is endowed with mere sensation and locomotion, where there is no central organ of circulation, and no organ of respiration but what is generally diffused over the

frame, the nerves are extremely simple; they consist of two cords running in the length of the body, with branches going off laterally to the several divisions of the frame. And here no intricacy is to be seen, no double supply of nerves is to be observed, but each portion of the frame has an equal supply; and the central line of connection is sufficient to combine the actions of the muscles, and to give them the concatenation necessary to locomotion.

There is the same uniform and symmetrical system of nerves in the human body as in the leech or worm; although obscured by a variety of superadded nerves. These additional nerves belong to organs, which, tracing the orders of animals upward, are observed gradually to accumulate until we arrive at the complication of the human frame. These nerves, additional and superadded to the original system, do not destroy, but only obscure that system; and accordingly, when we separate certain nerves, the original system of simple constitution is presented even in the human body.

The nerves of the spine, the tenth or sub-occipital nerve, and the fifth or trigeminus of the system of WILLIS, constitute this original and symmetrical system. All these nerves agree in these essential circumstances; they have all double origins; they have all ganglia on one of their roots; they go out laterally to certain divisions of the body; they do not interfere to unite the divisions of the frame; they are all muscular nerves, ordering the voluntary motions of the frame; they are all exquisitely sensible; and the source of the common sensibility of the surfaces of the body: when accurately represented on paper, they are seen to pervade every part; no part is without them; and yet they are symmetrical and simple as the nerves of the lower animals.

If the nerves be exposed in a living animal, those of this class exhibit the highest degree of sensibility; while, on the contrary, nerves not of this original class or system, are comparatively so little sensible, as to be immediately distinguished; in so much that the quiescence of the animal suggests a doubt whether they be sensible in any degree whatever. If the *fifth nerve, and the portio dura of the seventh*, be both exposed on the face of a living animal, there will not remain the slightest doubt in the mind of the experimenter which of these nerves bestows sensibility. If the nerve of this original class be divided, the skin and common substance is deprived of sensibility; but if a nerve not of this class be divided, it in no measure deprives the parts of their sensibility to external impression.

More particularly of the respiratory nerves.

The nerves which connect the internal organs of respiration with the sensibilities of remote parts, and with the respiratory muscles, are distinguished from those of which we have been speaking by many circumstances. They do not arise by double roots; they have no ganglia on their origins; they come off from the *medulla oblongata* and the upper part of the spinal marrow; and from this origin, they diverge to those several remote parts of the frame which are combined in the motion of respiration. These are the nerves which give the appearance of confusion to the dissection, because they cross the others, and go to parts already plentifully supplied from the other system.

The following are the nerves to be enumerated as *respiratory nerves*, according to their functions.

1. *Par vagum*, the eighth of WILLIS, the *pneumogastric nerve* of the modern French physiologists. This nerve goes off from the common origin of the respiratory nerves, the lateral part of the *medulla oblongata;* it takes its course to the larynx, the lungs, the heart and stomach. It associates these organs together, which are at the same time supplied with nerves from other sources. Comparative anatomy would lead us to infer that this nerve is not essential to the stomach, as it does not exist but where there are heart and lungs to associate with a muscular apparatus of respiration. That the stomach must be associated with the muscular apparatus of respiration, as well as the lungs, is obvious, from the consideration of what takes place in vomiting and hiccough, which are actions of the respiratory muscles excited by irritation of the stomach.

2. *Respiratory nerve of the face*, being that which is called *portio dura* of the seventh. This nerve, like the last, goes off from the lateral part of the *medulla oblongata*, and, escaping through the temporal bone, spreads wide to the face. All those motions of the nostril, lips, or face generally, which accord with the motions of the chest in respiration, depend solely on this nerve. By the division of this nerve the face is deprived of its consent with the lungs, and all expression of emotion. This part of the enquiry will be found very interesting.

3. *Superior respiratory nerve of the trunk;* being that which is called *spinal accessory*. This nerve has exceedingly puzzled anatomists, from the singular course which it pursues. It arises from the superior part of the spinal marrow, in a line with the roots of the other respiratory nerves. Instead of

going directly out betwixt the vertebræ, as the regular spinal nerves do, it passes up into the skull, comes out through the skull with the par vagum, and, descending upon the neck, goes to the muscles of the shoulder. In this course it supplies muscles which are already profusely supplied by the regular system of nerves.

This nerve controuls the operations of the muscles of the neck and shoulder in their office as respiratory muscles, when, by lifting the shoulders, they take the load from the chest, and give freedom to the expansion of the thorax. When it is cut across in experiments, the muscles of the shoulder, which were in action as respiratory muscles, cease their co-operation, but remain capable of voluntary actions.

4. *Great internal respiratory nerve.* The *phrenic*, or *diaphragmatic*, of authors. This is the only nerve of the system which has been known as a respiratory nerve. Its origin, course, and destination, are so familiar to every one, that I shall not say anything more of it here. But there is another nerve, which has a remarkable resemblance to it, and which, from circumstances already noticed, has been entirely overlooked. This is

5. *The external respiratory nerve.* This has a similar origin with the preceding nerve. It comes out from the cervical vertebræ, and is connected with the phrenic nerve. It runs down the neck, crosses the cervical and axillary nerves, passes through the axilla, and arrives on the outside of the ribs, where, it is scarcely necessary to observe, the muscles are already supplied by nerves coming out betwixt the ribs from the system of regular nerves.

These four last mentioned nerves govern the muscles of

the face, neck, shoulders, and chest, in the actions of excited respiration, and are absolutely necessary to speech and expression. But there are other nerves of the same class which go to the tongue, throat, and windpipe, no less essential to complete the act of respiration. These are the glossopharyngeal nerve, the lingual, or ninth of WILLIS, and the branches of the par vagum to the superior and inferior larynx.

We proceed to examine these nerves in detail, and first

*Of the nerves of the face, in which it is shown that the two sets of nerves, hitherto supposed to be similar, differ in structure, sensibility, and function.**

It is in the face, that we have the best opportunity of observing the subservience of the nerves to the uses of the parts, and of ascertaining the truth of the preceding doctrines. The human countenance performs many functions: in it we have combined the organs of mastication, of breathing, of natural voice and speech, and of expression. These motions are performed directly by the will; here also are seen signs of emotions, over which we have but a very limited or imperfect controul; the face serves for the lowest animal enjoyment, and partakes of the highest and most refined emotions. Happily for our present object, the nerves, which in other parts of the frame are bound together for the convenience of distribution to remote parts, are here distinct, and run apart from each other until they meet at their extremities. They take different courses through the bones of the head, and come out upon the face, to be exposed in a manner which courts enquiry.

* This subject is illustrated by Plate XXX. which represents the nerves of the face.

The nerves of the face are, first, the *trigeminus*, or the *5th of* WILLIS, and that familiarly called the *portio dura* of the seventh, but which, in this paper, will be called *the respiratory nerve of the face.*

Of the trigeminus, or fifth pair.

In all animals that have a stomach, with palpi or tentacula to embrace their food, the rudiments of this nerve may be perceived; and always in the *vermes*, that part of their nervous system is most easily discerned which surrounds the œsophagus near the mouth. If a feeler of any kind project from the head of an animal, be it the antenna of the lobster or the trunk of an elephant, it is a branch of this nerve, which supplies sensibility to the member, and animates its muscles. But this is only if it be a simple organ of feeling, and is not in its office connected with respiration.

From the nerve that comes off from the anterior ganglion of the leech, and which supplies its mouth, we may trace up through the gradations of animals a nerve of taste and manducation, until we arrive at the complete distribution of the fifth, or trigeminus in man (see Plate XXX. B. C. D. which are its three grand divisions to the face.) Here in the highest link, as in the lowest, the nerve is subservient to the same functions. It is the nerve of taste, and of the salivary glands; of the muscles of the face and jaws, and of common sensibility. This nerve comes off from the base of the brain in so peculiar a situation, that it alone, of all the nerves of the head, receives roots both from the medullary process of the cerebrum and of the cerebellum. A ganglion is formed upon it near its origin, though some of its filaments pass on without entering into the ganglion. Before passing out of the skull

the nerve splits into three great divisions, which are sent to the face, jaws, and tongue. Its branches go minutely into the skin and enter into all the muscles, and they are especially profuse to the muscles which move the lips upon the teeth.

*Of the respiratory nerve of the face, being that which is called portio dura of the seventh.** (Plate XXX. A *a b c d*).

This nerve does not exist except where there is some consent of motions established betwixt the face and the respiratory organs. In fishes, this nerve, instead of being distributed forward to the face, passes backward to the muscles of the gills. In fact, there is, properly, no *portio dura* of the seventh in fishes, the nerve resembling it being a branch of the *par vagum*. A short description of this nerve in the human body will be necessary to our enquiry.

The respiratory nerve of the face arises from the superior and lateral part of the *medulla oblongata*, close to the *nodus cerebri*, and exactly where the *crus cerebelli* joins the *medulla oblongata*. The other respiratory nerves, which form so distinguished a part of the nervous system, arise in a line with the roots of this.

The nerve, passing into the internal auditory foramen, is here embraced by the *portio mollis;* but it separates from it, and is received into an appropriate canal of the temporal bone. A little farther on, and while within the temporal bone, two cords of communication are formed with the branches of the fifth nerve, or *trigeminus*. One of these is called Vidian nerve, and the other *corda tympani*. By these communications,

* *Portio dura nervi acustici. Sympathetic parvus* by WINSLOW, *Faciale* by *Vicq. d'Azyr.*

nerves go in both directions; branches of the seventh are sent to the membrane of the nose, and to the muscles at the back of the palate; while branches of the fifth nerve (and also of the sympathetic nerve) are brought into the interior of the ear.

By the second of these communications, the *corda tympani*, [which joins the lingual branch of the fifth, just where that nerve is passing by the side of the *levator* and *circumflexus palati*,] the branches of this respiratory nerve have access to the *velum palati* and its muscles.

The respiratory nerve of the face, emerging through the stylomastoid foramen, divides into many branches, and these diverging, spread to all the side of the face. First, a branch is sent to the muscles of the outward ear; another is sent, under the angle of the jaw, to the muscles of the throat. The principal nerve then passes through the parotid gland and comes upon the face. Here the branches continue to scatter, to go upwards upon the temple, and downwards upon the side of the neck, forming on the neck a superficial plexus. The principal branches, however, go forward to the muscles of the forehead and eyelids; a branch called superior facial is sent to the muscles of the cheek and the side of the nose; while an inferior facial branch is given to the angle of the mouth and the muscles which concentrate there.

In this extensive distribution, the nerve penetrates to all the muscles of the face: muscles, supplied also with the branches of the fifth pair. Its branches penetrate to the skin, accompanying the minute vessels of the cheek.

The descending or inferior divisions, which go under the lower jaw and to the superficial muscles of the throat and

neck, are connected with branches of the spinal nerves, and with the respiratory nerves, as may be seen in the adjoined plate.

Its structure.

When we minutely observe the texture of the respiratory nerve of the face, we find it to correspond with the structure of the *par vagum*, and to differ from that of the *trigeminus*. The filaments of this nerve have a very close texture, like a minute plexus. The fifth, compared to it, has large free round filaments, with less intricacy in their texture.

If we were barely to consider this distribution of the *portio dura* of the seventh, unbiassed by theory or opinion, we should be forced to conclude, that it is not alone sufficient to supply any one part with nervous power, for every one of its branches is joined by divisions of the fifth. The question then naturally arises, whether these nerves perform the same function? whether they furnish a double supply of the same property or endowment, or whether they do not perform different offices? having taken all the assistance that the knowledge of the human structure and comparative anatomy afford, we are prepared to decide the matter by experiment.

Experiments on the nerves of the face.

An ass being thrown, and its nostrils confined for a few seconds, so as to make it pant and forcibly dilate the nostrils at each inspiration, the portio dura was divided on one side of the head; the motion of the nostril of the same side instantly ceased, while the other nostril continued to expand and contract in unison with the motions of the chest.

On the division of the nerve, the animal gave no sign of

pain; there was no struggle nor effort made when it was cut across.

The animal being untied and corn and hay given to him, he eat without the slightest impediment.

An ass being tied and thrown, the superior maxillary branch of the fifth nerve was exposed Touching this nerve gave acute pain. It was divided, but no change took place in the motion of the nostril; the cartilages continued to expand regularly in time with the other parts which combine in the act of respiration; but the side of the lip was observed to hang low, and it was dragged to the other side. The same branch of the fifth was divided on the opposite side, and the animal let loose. He could no longer pick up his corn; the power of elevating and projecting the lip, as in gathering food, was lost. To open the lips the animal pressed the mouth against the ground, and at length licked the oats from the ground with his tongue. The loss of motion of the lips in eating was so obvious, that it was thought a useless cruelty to cut the other branches of the fifth.

This experiment of cutting the respiratory nerve of the face, or *portio dura*, gave so little pain, that it was several times repeated on the ass and dog, and uniformly with the same effect. The side of the face remained at rest and placid, during the highest excitement of the other parts of the respiratory organs.

When the ass, on which the respiratory nerve of the face had been cut, was killed, which was done by bleeding, an unexpected opportunity was offered of ascertaining its influence, by the negation of its powers on the side of the face where it was cut across.

When an animal becomes insensible from loss of blood, the impression at the heart extends its influence in violent convulsions over all the muscles of respiration; not only is the air drawn into the chest with sudden and powerful effort, but at the same instant the muscles of the mouth, nostrils, and eyelids, and all the side of the face, are in a violent state of spasm. In the ass, where the respiratory nerve of the face had been cut, the most remarkable contrast was exhibited in the two sides of its face; for whilst the one side was in universal and powerful contraction, the other, where the nerve was divided, remained quite placid

From these facts we are entitled to conclude, that the *portio dura* of the seventh, is the respiratory nerve of the face; that the motions of the lips, the nostrils, and the velum palati are governed by its influence, when the muscles of these parts are in associated action with the other organs of respiration. These passages to the lungs are membranous tubes, moved by muscles, which serve to expand and widen them, so that the air may freely enter into the lungs. It is obvious that to produce this, these muscles must have a consent with the other muscles of respiration, and move simultaneously with them; and this is effected through the respiratory nerve of the face. It shall be proved in the sequel, that the throat, neck, shoulders, and chest, have similar nerves to this, similar in structure and function, and that these unite all the extended apparatus of breathing and speaking.

The actions of sneezing and coughing are entirely confined to the influence of the respiratory nerves. When carbonate of ammonia was put to the nostrils of the ass whose respiratory nerve had been cut, that side of the nose and face

where the nerves were entire, was curled up with the peculiar expression of sneezing; but on the other side, where the nerve was divided, the face remained quite relaxed, although the branches of the fifth pair and the sympathetic were entire. The respiratory nerve of one side of the face of a dog being cut, the same effect was produced; the action of sneezing was entirely confined to one side of the face.

These last experiments show, that the peculiar expression in sneezing, results from an impression on the respiratory nerves, and that the muscles of the face are drawn into sympathy solely by the influence of the respiratory nerve of the face.

There is no part of the nervous system where the anatomy has been more negligently consulted in forming our physiological opinions, than in what regards the office of the sympathetic nerve. The connections of this nerve, or rather system of nerves, being universal, it has been supposed that it was the chord through which the relations of the eye, nose, face, throat, diaphragm, &c. were established; whereas the combination is effected solely through those nerves which, from their grand or leading function, I have called the respiratory nerves.

It has been presumed, that the act of smiling is peculiar to the human countenance, and that in no other creature can there arise that state of enjoyment which produces this distinguishing character of the human face, the expression of benevolence, or of the enjoyment of the ridiculous. But every one must have observed how near the approach is to this expression, in a dog when he fawns on his master, and leaps and twists his body and wags his tail, while, at the same time,

he turns out the edge of the lips as like a laugh as his organs can express. When the respiratory nerve on one side of the dog's head was cut across, this motion of the lips no longer took place, although it was still observable on the other side, where the nerve was entire.

On cutting the respiratory nerve on one side of the face of a monkey, the very peculiar activity of his features on that side ceased altogether. The timid motions of his eyelids and eyebrows were lost, and he could not wink on that side; and his lips were drawn to the other side, like a paralytic drunkard, whenever he showed his teeth in rage.

We have proofs equal to experiments, that in the human face the actions of the muscles which produce smiling and laughing, are a consequence of the influence of this respiratory nerve. A man had the trunk of the respiratory nerve of the face injured by a suppuration, which took place anterior to the ear, and through which the nerve passed in its course to the face. It was observed that, in smiling and laughing, his mouth was drawn in a very remarkable manner to the opposite side. The attempt to whistle was attended with a ludicrous distortion of the lips; when he took snuff and sneezed, the side where the suppuration had affected the nerve remained placid, while the opposite side exhibited the usual distortion.

Thus, it appears, that whenever the action of any of the muscles of the face is associated with the act of breathing, it is performed through the operation of this nerve. I cut a tumor from before the ear of a coachman: a branch of the nerve which goes to the angle of the mouth was divided. Some time after he returned to thank me for ridding him of a

formidable disease, but complained that he could not whistle to his horses.

Of the function of the trigeminus, or fifth nerve, as illustrated by these experiments.

We have seen that when the fifth nerve, the nerve of mastication and sensation, was cut in an ass, the animal could no longer gather his food. In the individual whose face was paralyzed on one side during the excited state of the respiratory organs, there could be observed no debility or paralysis in the same muscles when he took a morsel into his mouth, and began to chew.

By an experiment made on the 16th of March, it was found, that on cutting the infra-orbitary branch of the fifth nerve on the left side, and the *portio dura*, or respiratory, on the right side of an ass, the sensibility to pain on the right side, where the *portio dura* of the seventh nerve was cut, remained entire, while that of the left side was completely destroyed by the division of the fifth. It was also apparent in this experiment, as in the others, that there was the most marked difference in the sufferings of the animal, when these nerves were cut across. The cutting of the fifth nerve gave pain in a degree corresponding with our notions of the sensibility of nerves; but in cutting the *portio dura*, it was not evident that the animal suffered pain at all.

Independently of the difference of sensibility in these nerves, there was exhibited in all these experiments a wide distinction in their powers of exciting the muscles. The slightest touch on the portio dura, or respiratory nerve, convulsed the muscles of the face, whilst the animal gave no sign of pain.

By means of the branches of the fifth nerve, it was more difficult to produce any degree of action in the muscles, although, as I have said, touching the nerve gave great pain.

I divided the branch of the fifth pair, which goes to the forehead, in a man, at his urgent request, on account of the *tic douloureux*: there followed no paralysis of the muscles of the eyebrow; but in an individual where an ulcer and abscess seated anterior to the tube of the ear affected the superior branch of the respiratory nerve, the eyebrow fell low, and did not follow the other when the features were animated by discourse or emotion.

It will be asked, why a nerve called *respiratory*, should go to the ear and the eye? First, let us enquire, does it belong to the frame of animal bodies that there shall be in them indications of passion? If it be admitted that this is the case, we here learn in addition, that as the *portio dura* is the nerve of respiration, so is it the grand nerve of expression, not only in man, but in brutes also. All that excitement seen in a dog's head, his eyes, his ears, when fighting, disappears, if this nerve be cut. The respiratory nerve being cut across in a terrier, the side of the face was deprived of all expression, whether he was made to crouch, or to face an opponent and snarl. When another dog was brought near, and he began to snarl and expose his teeth, the face, which was balanced before, became twisted to one side, to that side where the nerve was entire; and the eyelids being, in this state of excitement, very differently affected, presented a sinister and ludicrous expression.

On cutting the respiratory nerve of the face in the carnivorous animals, it did not appear that the action of feeding

was left so entire as in the graminivorous animals. This leads us to reflect on the different natures of the two classes. The beast of prey procures his food under the influence of a blood-thirsty appetite, and suffers a universal excitement; he holds and rends his prey; and especially in the larger animals of this class, the action of feeding is accompanied with horrific sounds of enjoyment: in short, with a highly excited state of the organs of respiration. In the graminivorous animals, the act of feeding is a simple and unempassioned exercise of the organs of mastication.

The author hopes that these experiments will be deemed conclusive; yet it is a pleasanter mode of investigation to have recourse to comparative anatomy. There is only one additional instance of this kind that he will offer. It has been already stated that when a feeler, or antenna, is examined, if it be simply for sensation, one nerve only runs along it. It was suggested to him, that if his theory were true, the trunk of the elephant being hollow, and connected with respiration, it should have two nerves; whereas in the observations of CUVIER it was stated to have only one. An opportunity of ascertaining the truth of this was very liberally granted by Mr. HERBERT MAYO, who had lately a young elephant for dissection. The two nerves were readily found, both of great size; the one a continuation of the superior maxillary branch of the fifth, the other a continuation of the respiratory, or seventh.

Having brought this investigation to a conclusion, some perhaps, fatigued by its details, may ask to what does this discussion lead?

Were we to enquire no farther, and to rest content with

the inference, that the two sets of nerves distributed to the face have distinct functions; even this must prove useful both to the surgeon and physician. To the surgeon it must be useful, in performing operations on the face, as well as in observing the symptoms of disease; but especially to the physician must these facts be important; he will be better able to distinguish between that paralysis which proceeds from the brain, and that partial affection of the muscles of the face, when, from a less alarming cause, they have lost the controuling influence of the respiratory nerve.

Cases of this partial paralysis must be familiar to every medical observer. It is very frequent for young people to have what is vulgarly called a blight; by which is meant, a slight palsy of the muscles on one side of the face, and which the physician knows is not formidable. Inflammations of glands seated behind the angle of the jaw will sometimes produce this. All such affections of the respiratory nerve will now be more easily detected; the patient has a command over the muscles of the face, he can close the lips, and the features are duly balanced; but the slightest smile is immediately attended with distortion, and in laughing and crying the paralysis becomes quite distinct.

The knowledge of the sources of expression teaches us to be more minute observers. The author had lately to watch the breathing of an infant which had been several times restored from a state of insensibility. At length the general powers fell low without any returning fit; insensibility and loss of motion stole over the frame; all but the actions excited by the respiratory nerves ceased; then each act of respiration was attended with a twitching of the muscles of the *ala nasi*,

and of that muscle of the cheek which makes the dimple in smiling. It was then evident that the child could not recover; that all but the system of respiratory nerves had lost their powers; that the features, as far as they were subject to the influence of the other nerves, had fallen.

There are conditions of the lungs, when the patient is in great danger, and yet the inflammation is not marked by the usual signs of pain and difficult motion of the chest. We shall see nothing but the twitching of those muscles of the face, which are animated by the respiratory nerve. We see a certain unusual dilatation of the nostrils, and a constrained motion of the lips, which with the change of voice is just sufficient to give alarm, and indicate the patient's condition. This is a state of the lungs very often produced after severe accidents, as gun-shot wounds, and after great surgical operations.

These circumstances are stated to prove, that the subject of expression is not foreign to medical studies; and certainly, by attention to the action of the muscles of the face, we shall find the views drawn here from the anatomy, farther countenanced. We learn that smiling is an affection of the nerve of respiration on the muscles of the face, and that when laughter shakes the sides, it is only an extended and more convulsive action of the muscles produced by the same class of nerves. When to the paleness and coldness and inanimation of grief, there is added the convulsive sob and the catching of the throat, and the twitching of the lips and nostrils, we discover the same class of nerves to be affected, which, in crying, are only more obviously in operation, producing more violent contractions.

In all the intermediate emotions between these extremes, the varieties of expression in the face are produced by the opposition of the two powers affecting the same muscles; the one is a voluntary power, by which we restrain the features and conceal emotion; the other is an involuntary power, which cannot be always controuled, but which will sometimes have sway and mingle its influence.

Conclusion.

When the account of the nerves of the throat, neck, and chest, shall be laid before the Royal Society, as those of the face have now been, and when a comparison shall be made of the varieties in nerves corresponding with the changes in the mechanism of respiration in different animals, a juster estimate may be formed of the importance of these observations. Then the same distinctions of structure and function, which are made manifest in the nerves of the face, will be observed in nerves which take an extensive course through the body. We shall be able to distinguish and separate the nerves of respiration, amidst the apparent intricacy of the general system. By cutting across these nerves of respiration, we shall find it possible successively to stop the motions of the several parts, which unite in the act of respiration; not only to stop the motion of the diaphragm, but the motions of the side, of the shoulder, of the larynx or the pharynx, by cutting their respective respiratory nerves. When this is done, they will be left in the exercise of their other functions through their other nerves, and still alive to other excitements, and capable of performing the voluntary motions, though dead to the influence of the heart and lungs.

By thus distinguishing the nerves of respiration, and as it were separating them from the others, we reduce the remaining part of the nervous system to comparative simplicity. The seeming intricacy in the branching of the nerves, their convergence to certain organs from different origins, their re-union and divergence, instead of being a source of confusion, becomes a subject of the highest interest. The re-union and crossing of nerves we now ascertain to be for the purpose of associating the muscles into different classes, for combining them in subserviency to different organs, and placing them under the guidance of a sensibility more certain in its operation than the will.

By these observations, simplicity and arrangement are now the characters of our anatomical demonstrations, and a better foundation is afforded for discovering and comprehending the symptoms of disease.

EXPLANATION OF PLATE XXX.

This engraving represents the nerves of the face, in illustration of the paper on that subject.

A is the *respiratory nerve* of the face, or the portio dura of the seventh, according to the system of WILLIS.

a. Are branches of this nerve ascending to the temple, where also branches of the fifth nerve may be seen coming out above the jugum.

b. Branches of this nerve ascending to the muscles of the forehead and eyebrow.

c. A large division of the respiratory nerve which goes to the muscles of the mouth and to the integuments of the cheek, where they accompany the blood-vessels that suffuse the cheek.

d. A union of the anterior branches of this nerve, from which pass off several nerves to the muscles of the mouth; and a branch somewhat more remarkable which advances to the muscles of the *ala nasi.*

e. f. g. A superficial plexus of nerves formed on the side of the neck by this respiratory nerve, or *portio dura;* and the branches of the cervical nerves; and the phrenic nerve.

h. Other remarkable connections formed between the phrenic nerve, the *descendens noni,* and the respiratory of the face.

B. The frontal branch of the *trigeminus,* or fifth nerve.

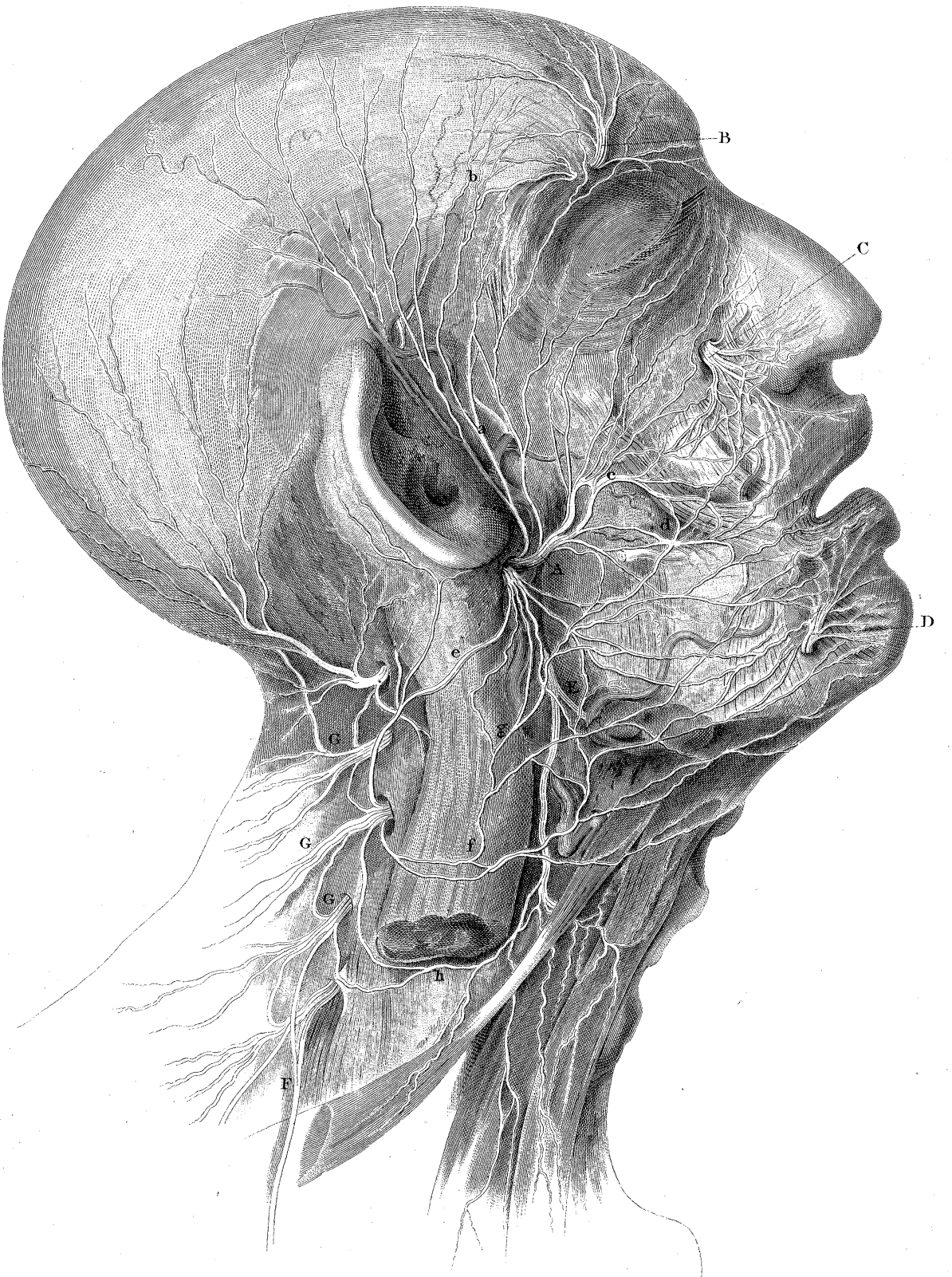
C. The infra-orbital division of the same fifth nerve. This branch is large and its subdivisions form a plexus before finally dividing to supply the muscles of the nostril and lip.

D. The third grand division of the fifth nerve, or *mandibulo-labralis,* to the muscles and integuments of the chin and lower lip.

E. The ninth nerve or *lingualis.* Its descending branch will be distinguished, connected with the respiratory of the face, the spinal nerves, and the phrenic. It is also connected with the superior respiratory nerve; but that nerve is not represented here.

F. The phrenic nerve, or internal respiratory nerve.

G. G. G. Cervical nerves.



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