Three papers on the nerves of the encephalon, as distinguished from those arising from the spinal marrow / by Sir Charles Bell.

With Sir C. Bell's compliments.

THREE PAPERS

ON THE

NERVES OF THE ENCEPHALON,

AS DISTINGUISHED FROM THOSE ARISING FROM THE

SPINAL MARROW.

BY

SIR CHARLES BELL.

From the TRANSACTIONS OF THE ROYAL SOCIETY OF EDINBURGH.
VOL. XIV.
(Read 2d April, 9th April, and 9th May 1838.*)*

EDINBURGH:
PRINTED BY NEILL & COMPANY.
MDCCCXXXVIII.

It is expected that AUTHORS who receive separate Copies of their Papers, will prevent them from being reprinted till one Month after the Publication of the Volume in which they are inserted.

By Order of the Council,

JOHN ROBISON, SEC.

Of the Third Pair of Nerves, being the first of a series of papers in explanation of the difference in the origins of the Nerves of the Encephalon, as compared with those which arise from the Spinal Marrow. By Sir CHARLES BELL, *K. H., F. R. SS. L. & Ed., M. D. H. Gott., &c.*

(Read 2d April 1838.)

IT is not a little remarkable, that in an age which assumes to itself the character of devotion to science, in anatomy, a science which embraces the best interests of humanity, this question should remain unanswered; *What is the meaning of the nerves of the spinal marrow being in regular order and perfectly symmetrical: whilst the ten nerves arising from the brain present no similarity one to another, and agree neither in origin, size, nor distribution?*

It is plain that we must be in the dark, not only with respect to the knowledge of the nervous system, but of the animal frame generally, whilst such a question is open and courts inquiry, and yet remains without an effort being made towards its solution. We must, I fear, attribute this neglect in part only to the difficulty of the inquiry, and much to the indifference to all that does not tend directly to profit; on which account it has the better demand on the attention of a learned and philosophical Society.

So far back as the year 1811, I ventured to announce this principle, *that in the nervous system a filament possessed the same endowment, performed the same function through its whole course, whether that filament be in a nerve, or traced from the nerve into the spinal marrow, or from the spinal marrow into the brain.*

The truth of this is apparent as soon as expressed, and inquiries directed on this principle have given it countenance and importance. It enabled me to shew that what was called a common nerve, being such as was supposed to possess all the vital properties, consisted of two nerves joined in the same sheath—one presiding over motion, and the other the seat or organ of sensation. Following out the principle, I found that the roots of the so-called "common" nerves differing in function, arose from distinct columns of the spinal marrow, and that these columns corresponded with the roots of the nerves to which they gave origin. That is to say, that the anterior of these columns presided over motion, and the other over sensation: That they were distinct, but not separated in their course, and preserved their parallelism and resemblance even till lost in the cerebrum. For at the point where the anterior columns join, and decussate in the medulla

oblongata, a similar junction and decussation takes place between the posterior columns.

In tracing these columns upwards, we come on ground necessary to our present inquiry, viz.—the *Nodus Cerebri* or *Pons Varolii*. This most conspicuous part of the base of the brain is an intricate mass of fibres, whose commissures and columns interweave, and to what purpose? Can it be doubted that it is for general union?—in order that organs seated apart may be united through the connection of their nerves?

Below the *nodus*, the course of the columns is regular; above it, the course of the corresponding tracts is simple. Here, then, must be seated the mystery, since, but for this intricacy in the *nodus*, order and simplicity would be displayed throughout the whole nervous system. We are directed in this inquiry by another circumstance. When we consider the nerves of the Encephalon according to the enumeration of Willis (which hitherto has been the acknowledged system), and count them and describe their course, we find *six sent to the eye!* The 2d, 3d, 4th, 5th, 6th, and 7th, wholly or in part pass into the orbit, into a space not larger than a wallnut shell. It is obvious, that if we discover why these nerves crowd into the orbit, the reason of the variety in the nerves of the base of the brain must also be disclosed to us.

This consideration points to the organ which has most engaged philosophers of every age and country—the human eye.

There are many reasons for considering vision as the compound operation of the sense seated in the retina, and the sensibility to the muscular movement of the eyeball. But without entering upon this demonstration, it is sufficient to our present purpose that we observe the surprising power of muscular adjustment of the eye in the direction of its axis to the sensation in the retina, or in other words to the object contemplated—as when the attention is directed to the minutest speck,—or the property by which the eye follows objects in motion, the flight of a bird or the track of a bombshell.

Since, then, the relation between the motions of the eyeball and the sense enjoyed by the proper nerve of vision is intimate beyond all comparison, and, I had almost said, comprehension, our first inquiry may take this shape—Ought the motions of the eye, so necessarily conjoined with the proper sense of vision, to be trammelled by the complex relations of the general frame?—those motions which, from familiarity, appear the simplest possible, but which are in fact the most complex. There is not a muscle in the body, nor a system of muscles, in which combination to a very great extent is not necessary to action.

The spinal marrow is a system through which the whole body, and especially the four quarters, are combined in action. There is not a limb stretched out without a conforming motion and balancing of the whole body. Walking, running, leaping, swimming, exhibit instances of this combination of the limbs,

and of the trunk in consequence. The whole active machinery of the frame is in most intimate union.

If we consider the office of the eyes—the necessity for their free and uncontrolled motions—their sole dependence on the sensation in the retina—we shall be ready to acknowledge that they must be relieved from the train of concatenated actions which occurs in every movement of the frame besides. Thus unembarrassed, the *recti* muscles of the eye are suited to that sympathy, and that extraordinary minuteness of accordance with the state of sensation in the retina, which are necessary to vision.

Resuming the consideration of the columns of motion and sensation:—they may be traced up into the cerebrum; the great *crus cerebri* is formed of these combined columns, as each diverges, and is lost in the hemisphere. The column of motion is still anterior, so that the anterior part of the crus belongs to muscular action, and the posterior part to sensation.

Now, considering that the essential difference in these columns is this—that in the anterior, the course of impulse is outward from the *sensorium commune*, and inwards, or towards the sensorium in the posterior, the origins of all the nerves must conform, or the system is overthrown.

We look with increasing interest on the roots of nerves, as conclusive on this subject.

The *first* nerve, the olfactory, being traced backwards, divides into three roots, and disperses in the inferior part of the anterior lobe of the cerebrum, without the intervention of the columns, and without interference with them.

The *second* or *optic* nerve, though in direct contact with the column of motion, takes no origin from it; but in a long and circuitous course, under the name of *Tractus opticus*, turns round the *crus cerebri*, to fall into the rear or back part of the column of sensation; and so, is combined with those nerves, through which the impulse is towards the sensorium, or inwards.

Even on proceeding so far, it is fair to infer that a nerve of sense gives off no branch—that it can communicate no endowment—that it is unequal to confer either motion or sensation, or any property but that which is its limited office.

Further, if we take the pen, and trace the nerves of sense—the olfactory, optic, auditory, and gustatory—we shall find them all avoiding the anterior column, and falling into the back part of the sensitive column; so that already in part we perceive the cause of irregularity in the base of the brain, in the necessity of the nerves of sense avoiding the anterior column, to gain the posterior or sensitive column.

We come next to the *Third Nerve.* This nerve is distinguished from all others; its origin is peculiar, and its distribution limited. By universal consent, it has got the name of *motor oculi*, being distributed to the voluntary muscles of

the eye, and to none others; so that it directs the axis of the eye in vision, both controlling the muscles, and having the further property of conveying to the mind the impression of the condition of the muscles. I entertain this idea because it is a double nerve.

Its origin.—Our best authors describe this nerve as arising from the *crus cerebri*, and so it does, above all the intricacies of the nervous system. It does not enter into the mixture of originating filaments in the *pons* or *nodus*. It does not communicate with the decussation in the *medulla oblongata*. It is in direct communication with the brain. But its precise origin deserves more particular inquiry.

As I have elsewhere shewn, that the *crus cerebri* consists of two columns, one of motion, the other of sensation, and that the *corpus nigrum* divides these columns. If a section be made of the *crus*, just anterior to the origin of the third nerve, we shall find that we cut through the *corpus nigrum*. And now if we take the curette, and gently divide the two columns, and so separate them in the direction towards the root of this nerve, we shall divide or split it, shewing that part of it arises from the anterior column, and part of it from the posterior column. If we carefully dissect and lay out the third nerve, we have a very interesting view, as illustrative of its function, and of the nervous system in general. The roots, as they arise, and for some way in their course (see the Plate, Figs. 1 and 2), are in round distinct cords, running parallel to each other. They then join together, and form a dense body, in which the filaments are separated, rejoin, and are matted together, after which their progress is as a common nerve. Their distinct origin from the divisions of the *crus*—the two distinct fasciculi of parallel fibres—the course of these for some way without exchange of filaments, and then afterwards running into intimate union—are circumstances of much interest, as shewing the distinction of the *crus cerebri*, the distinct nature of the roots of the third nerve, and that it is a double nerve, dedicated to the finer motions of the eye, peculiar in its structure, and yet in conformity with the system which I have followed.*

A question is naturally suggested here, Is the third nerve a sensitive nerve, as well as a motor; and if so, how comes it that there is no regular ganglion on the root which it receives from the sensitive column?

This would incline me to believe, that the ganglionic root is an organization on the spinal nerves and fifth pair, suited to that sensibility which the body universally and the surface especially enjoys, which gives pain, and becomes a guard upon the frame.

* The objection which will be naturally suggested, is, that the *abducens* nerve arises behind the *pons*. We shall afterwards shew why it does so. And, let it not be forgotten, that the relations of this nerve are the cause of frequent disturbance to the condition of the eye, a consequence, certainly, of its greater complexity.

At the same time, it will not be overlooked, that the texture of the nerve at the union of the fasciculated roots very much resembles the texture of the spinal ganglion (Fig. 2, D). The difference may be reasonably attributed to the distinction in office, *i. e.* that it has no reference to the sensibility of the surface. but only to the condition of the muscle.

The very peculiar and unique position of the roots of this third nerve, whilst it places the function of volition directly in communication with the sensorium, and unembarrassed by communication with other nerves, has also this superior advantage, that it is in direct relation to the sensitive column. This connection, as I have just said, has no reference to common sensation, for the nerve is strictly limited to the muscles, but only to that property of estimating the condition of muscular activity.

We pass on to the consideration of the Fourth Nerve. To comprehend its relations, we must take a wide range, and a different course.

Of the Origin and Compound Functions of the Facial Nerve, or Portio dura of the Seventh Nerve;—being the Second Paper in explanation of the difference between the Nerves of the Encephalon, as contrasted with the regular Series of Spinal Nerves. By Sir CHARLES BELL, *K. H., F. R. SS. L. & Ed., M. D. H. Gott., &c.*

(Read 9th April 1838.)

IN following out the principle formerly laid down—that the study of the organization and functions of the part to which the nerve is distributed, will explain the peculiarities of its origin and connections—I have in this paper entered on a subject of great extent and difficulty.

As the *Facial Nerve* is one of a distinct class, it will be necessary to shew in what that class is peculiar—that it essentially belongs to the act of breathing—that the act of respiration being, in its ordinary condition, independent of the will, there are nerves appropriated to that function. At the same time, it must be shewn, as the apparatus of breathing is made subservient to other purposes in the economy, by what relations it is brought under the influence of the will.

The excited act of breathing extends to the features of the face; and the face, so influenced, is especially the seat of expression. The same parts are the instruments of speech. Hence, it appears, that the nerve which animates the features must have a compound root. It will be my object to shew that the facial nerve has an origin corresponding with its complex operations.

It has been affirmed that I have given up the term Respiratory Nerves. This betrays an ignorance of the whole subject. But as it may have arisen from my imperfect description, I beg the Society to permit me to illustrate this subject, as the necessary foundation of what I have to offer on the nerve of the face. In an inquiry of this kind, the observation of natural phenomena is more agreeable, and more conclusive, than experiments on living animals. With this object, let us notice the actions of the frame at a time when sense and volition are withdrawn.

It is sometimes the severe duty of the physician to watch the act of dying, and to mark its successive stages. A man is not dying, whilst yet the respiration is unembarrassed. But whether he die from violence and loss of blood, or by gradual exhaustion and lingering disease, the act may be said to commence with an excited state of the respiratory organs.

When the vision is clouded, and the eyes want speculation or direction, and

the hand is insensible to the pressure of affection, then the chest rises high at each inspiration, and the muscles of inspiration are prominent in action.

When, through increasing insensibility, the limbs lie relaxed and powerless, the muscles of the shoulders, neck, throat, and nostrils, are visibly excited, and at each inspiration (although we cannot say there is effort, that being an influence of the mind), yet each fibre of the class of respiratory muscles is like a cord in violent tension.

When the decay of life reaches the respiratory system, it first affects the lesser muscles which expand the air-tubes, the muscles of the *glottis* and *velum palati* lose their tone, and these parts becoming relaxed, vibrate in the inspiration of the breath, and cause stertor.

At length the regularity of the respiration is disturbed—there is an interval between the inspiration—the interval is prolonged and irregular, and the action returns with sudden violence, every muscle starts convulsively into action, but with no voluntary effort or struggle. The longer the interval of rest, the more sudden and startling is the return of action, and when we deem all at rest, once more the breath is drawn. At last the action ceases in the chest, whilst yet the throat and cheeks are pulled with a regular succession of actions, and the last fibre which answers to the presence of life, is the *Risorius Santorini* and muscles of the nostril. Two or three times the *Risorius* is drawn with spasmodic twitchings, and then all is still. It is the ultima moriens.

We can hardly miss noticing the resemblance here to natural sleep, the absence of all sense and voluntary motion, and the continuance of the respiration by a property of action which knows neither lassitude nor debility.

In a Society which does not reject the cultivation of literature with science, I may be permitted to quote the beautiful description of HALLER: "Nocte redeunte sensim torpor percipitur in musculis longis, ineptitudo ad cogitationes severiores, amor quietis in animo et corpore. Tunc peculiariter vires corpus erectum tenentes laborant, et oculi nolentes clauduntur, et maxilla inferior pendet, et oscitationis necessitas ingruit, et caput antrorsum nutat, et objectorum externorum actiones minus nos adficiunt, et denique turbantur ideæ," &c.

But, whilst the body, as far as it is subject to the mind, or subject to change through the will, or through passion, is thus at rest, a class of muscles of great extent, seated remote from each other, are combined in simultaneous action. No weariness or exhaustion reaches them. They are most perfect, most regular in action, whilst all besides are at rest.

Thus, we may contemplate the body under two conditions: *First*, Where all is animated, sensitive, and expressive: *Secondly*, Where the body has the semblance of death, and the active powers are at rest. It is natural to seek in the anatomy, and especially in the nervous system, for some correspondence in the structure: nor shall we have far to seek.

Having distinguished that symmetrical system of nerves, the functions of which are sensation and volition, we find nerves which at first appear superfluous. But these superadded nerves, although they produce, when entangled with the others, the appearance of extreme intricacy, are, when taken separately, regular also. For we trace all to a centre, and that centre giving them an origin and a source of power different from the other nerves.

When we see to what order of parts these nerves are distributed, it is impossible to refuse to them the term of Respiratory Nerves. The distinction of animal functions from vital and natural, has always been noticed, and the distinction explained on the supposition of distinct nerves ministering to each; which suggestion was resigned, because anatomists would not agree to any such distinction of nerves. Nevertheless the reasoning was just, and the objection of the anatomists unfounded.

Comparative anatomy affords us the most pleasing view of this respiratory system. From the lowest link of the chain of beings to the highest, there is a progressive series of nerves, increasing in complexity. It is natural to inquire, On what does this complexity depend? In the lower link of the chain of animals, we see the essential operation of decarbonization performed by the contact of air with the fluids circulating over all the frame. We see the same object attained by a sac or cavity, which admits the air, and which sac alternately opens and closes again in other creatures; such cavities communicate with the atmosphere through prolonged and intricate tubes. Witnessing all this, we also perceive the necessity of new nerves of connection. When we further see a new power or faculty bestowed by means of the air which plays through these tubes—voice issuing by their vibration; when we observe that the air drawn through the tubes is diverted into another channel, and made subservient to smelling; when, still ascending to the highest link of the scale, we find the faculty of speech bestowed through the same means,—it would be strange, indeed, if anatomy did not in the same ascending scale disclose an increasing number of nerves.

Again, in the mouth and in the throat are two passages. How shall the one only admit air, and the other food? How shall breathing, deglutition, and speech, coughing, vomiting, be performed, each action differing from another, in the arrangement of some fifty muscles of these tubes? How are these actions ordered, but by a minute and seemingly intricate supply of nerves?

In all animals, man included, the same symmetrical system of nerves, unvarying in any essential circumstance, is devoted to sensibility and locomotion. But the other system, that which is superadded, varies in a remarkable manner; comparatively simple in the animals which merely breathe, complex when the organs of breathing become instruments under the will, they are at once essential to life, and in their higher office minister to the qualities of mind. It would be a strange anomaly, if, with these new faculties, sympathies, and relations, there

were not also an increasing complication of nerves. This intricacy, this fine dependence of the functions, render experiments delusive and unsatisfactory. For we may divide a nerve, one which appears to our conception essential, and no consequent results! We cut a nerve going to the tongue or the throat, and the animal breathes, barks, and swallows. It would be dangerous therefore to conclude that the nerve were superfluous. It is only by an enlarged view of the anatomy that we shall be brought to just conclusions.

From this system I have to select one nerve, and shew how through it, two distinct offices—vital respiratory actions, and voluntary actions—are combined in the face.

The base of the brain being carefully taken out, without tearing the roots of the nerves, and the whole being for a twelvemonth preserved in spirits, we may commence the dissection. The *medulla oblongata* and *pons varolii* being cleared of their membranes, and the places of the *sixth* and ninth nerves noted, we clear and arrange the filaments of the eighth pair, and the *portio dura* of the seventh.

We see the *facialis* or *portio dura* of the seventh nerve coming out from the depth between the convexity of the *pons* or *nodus cerebri*, the *corpus olivare*, and the root of the auditory nerve. This nerve we have now to trace inwards, and in the substance of the *pons* or *nodus*.

We shall not find this nerve arising in separate filaments, but in a flat layer of nervous matter, which fan-like spreads into the nodus.

To understand the full consequence of this form of the root, we must make a section of the *nodus* or *pons*, to shew the manner in which the motor tract expands within it. Previous to this let the sixth nerve, and *portio dura* of the seventh, be thrown forwards, and the glosso-pharyngeal and nervus vagus laid aside. If we now dissect close round the corpus olivare, the motor column will be found bending round that body; and now, by following the root of the *portio dura* inwards, its origin from the column of voluntary motion will be apparent. One portion diverging towards the sixth nerve, the other towards the glosso-pharyngeal nerve. See Fig. 3, (6, 7, and 8,) also Fig. 4, in which the relations of the nerves are made more distinct. By proceeding differently, we obtain a better view of the common origin of the eighth pair and *portio dura*. Cut across the *processus ad cerebellum*, and open up the fourth ventricle. Trace the roots of the eighth pair inwards. You find the column from which they arise in the form of a *tractus* ascending to the *corpora quadrigemina*, the *valvula cerebri* forming the commissure of the two respiratory tracts. From this tract the *portio dura*, now viewed from behind, will be seen to take an origin.

We may now have a view of the relation of the respiratory nerves to the sensitive column of the *medulla oblongata*, either by tracing up the sensitive column from the spinal marrow, or by tracing down the sensitive root of the fifth nerve.

We shall now find that the eighth pair, that is to say, the *nervus vagus* and *glosso-pharyngeus*, is situated so as to draw roots from the sensitive column.

By such a mode of dissection, it will be found that the facialis or *portio dura* of the seventh nerve has direct connection with the motor and respiratory columns, and hardly less directly is related to the fourth and sixth nerves.

The facial nerve, thus arising, allies itself with the auditory nerve, and passes into the temporal bone. In its passage through that bone, it exchanges fibres with the branches of the fifth nerve, and after some intricacies, escapes by the *stylo-mastoid foramen*, to expand upon the cheek, and finally to reach every part on the side of the head, with the exception of the muscles of the jaws. Although its connection on the side of the neck countenances the view I am about to give of this nerve, yet we must draw our inferences chiefly from the origin and functions of the nerve.

Of the Function of the Facial Nerve, or Portio Dura.

In the facial nerve we have an organ of most complex operation. It combines the passages with the great internal organ of respiration. It animates the lips and cheeks in combination with the organs, so as to give both speech and expression. It is the source of all the sympathetic actions which illuminate the features in unison with the condition of the mind. It has some remarkable effects on the eyes, which subject we shall reserve to be taken apart from the present inquiry.

That the facial nerve is the respiratory nerve, I early shewed, by dividing it in brutes; when, although sensibility remained, all action in the face was cut off, excepting the motion of eating. Many occurrences in the practice of my profession have exhibited the same results from the same cause in man.

Though one of the most celebrated philosophers of our day, Dr YOUNG, asked rather querulously, "What had the face to do with respiration?" yet must it be obvious (unless, indeed, the mind be exclusively engaged in observing the chemical phenomena of the economy), that the tubes which give passage to the air, being soft and pliant, and subject to the pressure of the atmosphere, must be dilated, and their sides held apart by muscular action. How also are they to admit of breathing, and more especially, how is the expansion of the tubes to be adapted to the excited condition of breathing? I have already alluded to the stertor consequent on the relaxation of the tubes in apoplexy. And when this nerve is deprived of power, we find the relaxed lips playing in the act of breathing like the flapping of a sail.

It will not therefore be again asked, why a branch of that system of nerves which animates the organs of respiration extends to the lips and nostrils, as other branches tend to the *velum palati*, the throat and larynx.

Considering the nerve in this, perhaps its most important function, that is operating upon the tubes or passages for the breath, during sleep and insensibility, we have next to contemplate it, as combining the effort of the will in unison with that of respiration. It is in this combined exercise that we have to be most grateful for the effect,—the vibrations of the tubes modulated into articulate language,—the performance at once of that function most necessary to existence, and that faculty of speech essential to the developement of the powers of the mind as the *instrument* of thought.

Finally, the facial nerve is the source of expression. If the properties of this nerve through any accident be lost, accidentally cut across, pressed on by a tumour, or engaged in inflammation, the corresponding side of the face remains motionless and blank. The cheeks and lips are blown out like a window-blind. They have neither tension nor action. *Expression*, whether in laughter or in tears, and all the intermediate conditions, continue to influence the other side of the face, but with frightful distortions, pulling upon the side which has lost power.

There are instances recorded, now that the cause is understood, of entire loss of expression on *both* sides of the face. A young woman, in whom the roots of the nerve on both sides were involved in disease, exhibited the most distressing consequences,—for whether she laughed or cried, the features were immoveable. She laughed under a mask, a sad thing to witness, a light heart behind a face in the repose of death.

There is an animation coincident with speech, and a reflection of the mind in the human countenance, *at all times*. We have the full sense of this only from the effects of this nerve being cut, for then the features are completely fallen, more divested of expression than a mask or a bust, for it is not the fixed state of a *statue* which has *meaning*, but something worse than death.

If this condition of total inaction continue, the plumpness of the face is lost, and the skin becomes like a piece of parchment stretched over the bones. It is a remarkable thing to see, in one sense, the life and sensibility of the parts remaining, whilst there is a ruin of all which is a reflection of the mind. The muscles of the jaws, however, remain as powerful and active as before, having their energies excited through the nerves of the other system.

We now perceive the correspondence between the roots of the facial nerve and the offices it has to perform in the face. We recognise its double roots, its relation to two distinct columns in the performance of two distinct functions. We perceive its lively subjection to the will, because of its relation to the motor column, whilst its origin in common with the eighth pair of nerves explains to us how it is that the nostrils and lips move simultaneously with the other parts engaged in the act of respiration; in other words, how the vital actions through

the influence of this nerve are continued during the repose or annihilation of sensation and volition.

It is not possible to account for all the finer operations of the features by the investigations of anatomy. Yet we see that this nerve arises in most peculiar circumstances, that its roots are connected with the *nodus cerebri*, a name well chosen, since in it, without exaggeration, fibres are crossing in every possible direction. We may display these fibres, and we may suppose that each filament has its influence; but it is better to stop short of conjecture, and to rest on the demonstrated fact that this nerve is special, in one sense a double nerve, not, however, like the double nerves of the spine, where action and sensibility are conjoined, but double in as far as two modes of action are effected through it; one independent of mind, the other answering to its slightest emotions.

There is indeed nothing more remarkable than those distinct offices, and that variety in the motion of the features, arranged and controlled through a single nerve not larger than a thread, combining the features in the general act of respiration, giving utterance in speech, and indicating every degree and variety of emotion.

I had at one time been deceived into the belief that laughter, and all the changes of the face indicative of what is pleasurable or ludicrous, were but the result of the degrees of relaxation of the muscles, as it were a defect of action. Such an opinion is untenable when we perceive the consequences of the loss of this nerve, for its defect of influence, so far from giving place to a smile, reduces the features at once to the most painful and melancholy relaxation.

Laughter, and all the changes of the countenance indicative of pleasurable emotion, are neither the effect of relaxation nor of spasm incidentally produced. It is a balanced condition of the features, in which certain muscles are in activity, whilst others are thrown out of action. In the painful emotions, still influencing the features through the same nerve, another classification of muscular actions takes place; some muscles in tension, others incontrollably relaxed, both conditions, and all the intermediate states, are designed as the outward signs of passion; and from which are afforded the highest and the most unceasing gratification, a language which is the charm of life, and the bond amongst men.

But I am somewhat trespassing, and deviating from the proper object of the paper, which was to shew in what the facial nerve or *portio dura* is distinguished from the symmetrical nerves—that it is in a different sense a compound or double nerve, and that its roots correspond so far with its various functions.

In my next paper, I shall endeavour to shew the necessity of combination between the Facial Nerve and those which enter into the orbit.

EXPLANATION OF PLATE.

Fig. 1, A, B, Section of the *Crus cerebri.*

A, Motor column.

B, Sensitive column.

C, The Third Nerve, arising from both columns.

D, E, *Tractus opticus*, passing round the motor column.

Fig. 2, A, Section of right *Crus cerebri.*

B, Distinct fasciculi of the Third Nerve, arising from the muscular column.

C, Similar fasciculi of the nerve arising from the sensitive column.

D, The union of the fasciculi in a dense ganglionic texture.

Fig. 3, Represents the origins of the nerves from the *Pons Varolii* and *Medulla Oblongata.*

5, The Fifth Nerve in its two portions.

6, The Sixth pair ; the nerve of the right side unravelled.

P. D. 7, The Portio dura of the Seventh Nerve.

P. M. 7, The Portio mollis.

8, The Glosso-pharyngeal, Nervus vagus, and Spinal Accessory, forming the Eighth pair.

9, The Lingualis.

The foramina, both large and numerous, mark the provision for the entrance of blood-vessels, from which we may deduce the vital importance of the nerves.*

Fig. 4, An enlarged view of the roots of the Sixth, of the Portio dura or Facialis, and of the Glosso-pharyngeal nerve.

A, The Pyramidal body.

B, Corpus olivare.

* Consult the interesting paper by Sir Astley Cooper on the obstruction of the Vertebral Artery.

PLATE XIV.

Trans. Roy. Soc. of Edin. Vol. XIV. p. 236.

Fig. 3.

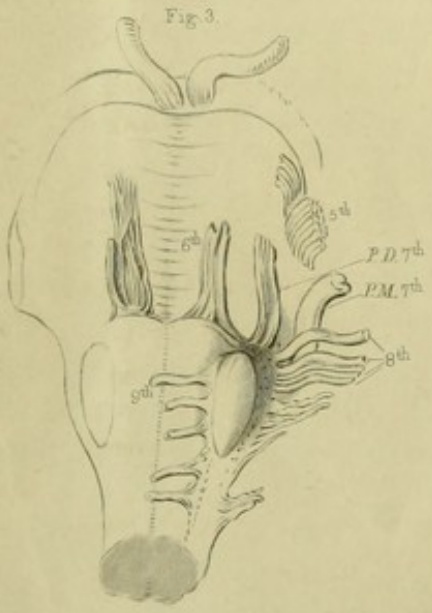


Fig. 2.

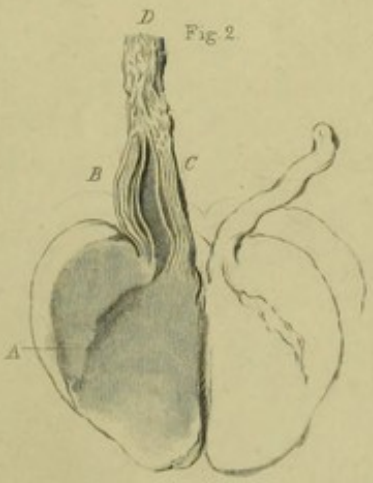


Fig. 4.

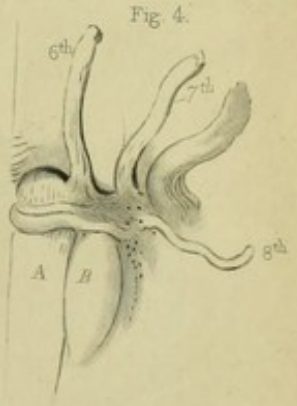
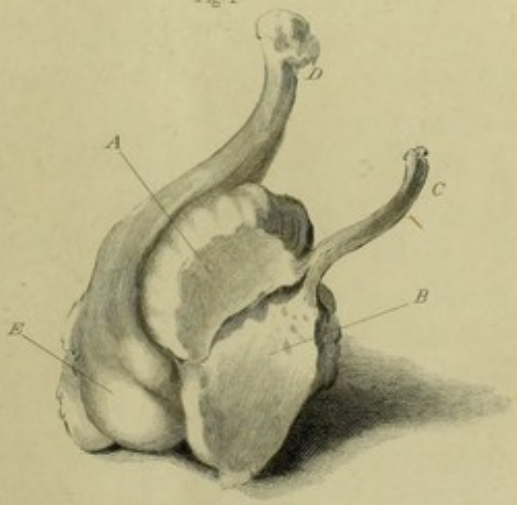


Fig. 1.



Sir C. Bell delt.

Of the Fourth and Sixth Nerves of the Brain ;—being the concluding paper on the distinctions of the Nerves of the Encephalon and Spinal Marrow. By Sir Charles Bell, *K. H., F, R. SS. L. & Ed., M. D. H. Gott., &c.*

Read 7th May 1838.

Interesting as theoptical properties of the eye have been to philosophers in every age, there are conditions of this organ which are no less curious, and which have not had their share of attention.

In the year 1823, I introduced the subject to the Royal Society of London, nearly in the terms I am now using, but there is much more in the subject than I then conceived, although I see no reason to change the mode of contemplating it.

The eight muscles of the eye, and the five nerves, exclusive of the optic nerve, which pass to them, imply the complex nature of the apparatus exterior to the globe, and I fear it is too plain that the subject has not been satisfactorily treated.

It is chiefly with respect to the protecting motions of the eye that the difficulty occurs, for I hope the dependence of the proper organ of vision on the voluntary muscles of the eye, has been proved and acknowledged.

Permit me to draw the attention of the Society to what appears a very simple piece of anatomy, the circular muscle which closes the eyelids, *orbicularis palpebrarum.*

It will be necessary to divide the muscle into three parts—and that not in an arbitrary manner, but according to the action of each division.

Around the margin of the orbit, there is a portion of the muscle red, fleshy, and strong—within it, and lying on the eyelids, there are fibres, which though they converge to the same point in the angle of the eye, are distinguishable from the outer circle by their delicacy and paleness. Lastly, the *ciliaris* is a thin slip of muscle which lies along the margin of the lower eyelid.

These divisions of the muscle authorized by Albinus and others, have different actions and different relations. The larger and external circle is brought into action when the eye is irritated or excited. The lesser paler fibres gently close the eyelids as in sleep, or in winking when the eyelids fall together in their usual rapid closing, to moisten the surface of the cornea,—an action which is quite peculiar, and so quick as not to interfere with the permanence of the impression on the retina.

The ciliaris draws the lower eyelid horizontally, and belongs properly to the *sacculus lacrymalis*, squeezing and emptying the sac.

Let us observe the necessity of certain relations between the larger and fleshy circle of the orbicularis when the eye is excited, as when something offensive is thrown into it. It is here necessary to notice the resemblance in action of the human eye to that of quadrupeds which possess the *haw*.

In the *caruncula lacrymalis* and *membrana semilunaris*, we have an apparatus less perfect, certainly, than that of the horse—but for the same purpose, to gather together and thrust out what is irritating the eye.

To the exercise of these parts, however, other muscles must consent, so that the cornea shall be turned in towards the inner *canthus* of the eye at the moment that the eyeball is forcibly squeezed by the action of the orbicularis. The difficulty which the oculist encounters, is to prevent the cornea turning into the lesser angle of the eyelids; for this direction of the eye towards the nose, is taken the instant that the knife or needle touches the eye. This action of the muscles which is a provision for the protection of the eye, is often the source of mishap in operation.

The position of the eyeball in which it is drawn towards the *os planum*, and the axis turned inwards, could not be the effect of the external orbicular muscle alone—nor could it be performed by the combined action of the recti. It is obvious that a relaxation must take place in the *rectus externus* or *abducens* muscle. How is this relaxation to be effected in correspondence with the action of the larger or outer portion of the *orbicularis?* There is no direct connection between these muscles: they do not touch: no nervous filaments pass between them. We must therefore turn to the origins of the nerves which supply these muscles. We find them related at their origins though proceeding by different courses to their destination.

Here let us consider the nature of that relation which exists between two classes of muscles engaged in any action. I mean not those only which are excited together to contraction, but those also which are relaxed, and which relaxation is as necessary to the effort or movement, as the contraction of their opponents.

In every action there are two conditions of the muscles, and philosophically considered, both might be called states of action, for that which is called relaxation, is not like the throwing loose of a rope which gives no resistance, but a condition of yielding, apportioned in the finest degree to the state of contraction of the other class.

This relation established between the two opposite classes of muscles is not always as in the limbs where they lie in juxta-position,—but often, more especially where the muscular action is related to the internal functions, muscles may be far apart, which yet through nervous connection are in intimate cor-

respondence, though in opposite conditions, the one contracted, the other relaxed.

And now as to the motions of the eye, we cannot be surprised if the muscle exterior to the eyelids, and the muscle lying deep in the socket should be related in the condition of relaxation and contraction, and that the relation should be established through the connection of their respective nerves at their roots—this is the matter to be enquired into.

Let us now attend to the relation of the lesser portion of the orbicular muscle—that paler set of fibres which lies on the eyelids.

When we recollect that the margins of the eyelids in closing, touch only at their outer edge, and that when closed, a gutter is left between them and the cornea, the winking of the eye, far from clearing the surface of the cornea, would suffuse it, by leaving the tear upon it, were it not that in the act of winking the eyeball is turned up. It is by this revolving of the ball, that the cornea is moistened and wiped clear.

How is this revolving motion of the eyeball accomplished? No action of the eyelids could produce this effect. It can only be done by the action of superior *rectus* or inferior oblique. It is not performed by the superior *rectus*, which I determined, by cutting that muscle in a monkey, when the upward rolling of the cornea continued accompanying the effort of the eyelids to close.

The two oblique muscles being opponents, the relaxation of the upper one will give power to the lower one, so that we have, as before, to seek for a relation between the paler fibres of the *orbicularis* and the superior oblique. The superior oblique stands in the same relation to the internal and paler circle of the *orbicularis* that the *abducens* or *rectus externus* does to the stronger exterior circle of the same muscle.

Thus brought to acknowledge the relation between the muscle seated on the eyelid and external, to a muscle seated deep in the orbit, and seeing no direct connection between them, we must turn once more to notice the relations which establish the connection at the roots or origins of their respective nerves.

By such study of the muscular apparatus of the eye, and their actions for the protection of the organ, we are following out the principle, that the structure and action of a part will direct us to the peculiarity of its nerves. That the eye stands distinguished from the other organs of sense by the multiplicity of its guards, is owing to its extreme delicacy of structure, and its necessary exposure.

In my second paper, I had occasion to notice that the *facial nerve*, or *portio dura* of the seventh, coming circuitously through the *foramen stylo-mastoideum* to supply the face, is the nerve also of the *orbicularis palpebrarum*, or, in other words, of the exterior muscles of the eyelids. It was also noticed, that the *facialis* at its origin is in direct relation with the sixth or *abducens* nerve. Now, this sixth nerve takes a direct course forwards into the bottom of the eye-socket,

crosses all the other nerves, and, though crowding with them into the orbit, forms no relation with them, but is altogether given to the abductor muscle.*

Again, in following the root of the *facialis*, and especially that portion of it which arises from the respiratory tract, we find a relation established between it and the root of the fourth nerve or *trochlearis*; and this delicate nerve passes forward like the other, enters the *foramen lacerum*, and gains the bottom of the orbit, touches no other nerve, but is wholly given to the superior oblique muscle.

If an objection should be made to the circuitous course of these nerves, as the source of the relations between the muscles, how else are the sympathies to be accounted for? and what interpretation are we to put upon the fact, that wherever there are *recti* and *obliqui* muscles of the eye,—wherever the eye possesses protecting motions, we find the same arrangement of the third, fourth, and sixth nerves, from man downwards.†

Surely it is time to read off the anatomy of the nervous system,—to seek for the relations of parts through their nerves,—to ask ourselves why there are such deviations in their course,—and why these deviations are constant, not in individuals only, but in the different classes of animals? If, with this view, we ask ourselves why the facial nerve takes a course different from the fifth, the functions of the part to which it is distributed do sufficiently inform us, that the features must be joined in sympathy or unison with the act of respiration. If we inquire why its branches reach to the eyelids, to the very part through which the branches of the fifth pass, we have only to notice the necessity for a guarding action of the eyelids in all excited conditions of the respiratory system. I need not here repeat my former observations.

In the same manner we may interpret the course of the spinal accessory nerve, or the reverted course of the recurrent of the *par vagum*.

In looking generally to the remarkable deviations in the course of the nerves, we shall find that they are confined to those which join distant parts in the act of breathing, or modify the act of breathing, as in speaking, swallowing, &c. No such irregularities are found in the system of nerves which minister to voluntary motion and sensation. They are distributed with a perfect symmetry or regularity.

And in the orbit, if we take away the respiratory of the face (the facialis), and the nerves resulting from that connection, viz. the fourth and sixth, the intricacy of the orbitary nerves is removed; there would remain one for vision, another for common sensibility, and a third for motion.

* Where there is a retractor muscle, this abducens nerve supplies it, which strengthens the supposition of a relation between the retraction of the eye and its simultaneous direction inwards.

† Taking the facts of the anatomy into account, and the actions of these muscles, the subject becomes of great interest, as connected with the expression in the eye.

In conclusion, and in explanation of the marked difference in the origin of the nerves of the spine and of the encephalon, we shall find that it is principally owing to the columns of motion and sensation.

1. All the nerves of Sense,—the olfactory, optic, auditory, not excepting the gustatory, though running into the base of the brain, must deviate from the anterior column, which is that of motion; and, accordingly, they twist round that column to enter directly into the sensorium (as the olfactory does), or to associate with the column of sensation, like the optic tractus, and roots of the auditory nerve.

2. The next source of irregularity of form and apparent intricacy in the base of the brain, is a consequence of the various sensibilities and active powers of the eye and its appendages, which require no fewer than six nerves to this one organ! Hence the ophthalmic of the fifth nerve, in addition to the proper optic nerve,—hence the motor independently of the fifth,—hence the sixth and the fourth, to associate the deep and superficial muscles of the eye and eyelids.

3. Another source of intricacy is the intrusion, as it were, of the fifth nerve among those of the encephalon. The fifth, a nerve of double root, a sensitive and motor nerve, a nerve with a distinct ganglion on its posterior root, I early announced to be a spinal nerve, that is, the anterior or (in the human body) the superior of the spinal nerves. This nerve not only giving motion to the jaws, but being the nerve of sensibility, mingles its branches with every other nerve, goes every where in the head and face, and enters into every organ, and is therefore a source of exceeding great intricacy, until the just principle be obtained.*

4. Lastly, a main source of intricacy in the nerves of the base of the brain, and of the whole nervous system, is the existence of a distinct source of motion independent of volition, and yet necessarily conjoined to it,—a source of power which shall govern the act of respiration, and yet permit a union of the apparatus of breathing with those of speech; for example, the necessity of joining the motion of the features with the pneumatic office of the lungs, being the cause of that deviation which we perceive in the facial nerve from those of simple volition.

In short the double origin and double function of the nerves of the spine is the reason of their uniformity and simplicity of distribution. The nerves of the brain differ from those of the spine, and from each other, inasmuch as each has a peculiar endowment, and necessarily a distinct origin. They therefore vary in course and distribution, and hence their apparent intricacy.

* The discovery of this fact has been caught at by men, as incapable of the induction which led to it, as of following it up in its consequences.