XXI. *Second Part of the paper on the Nerves of the Orbit.* By CHARLES BELL, *Esq.* *Communicated by Sir* HUMPHRY DAVY, *Bart. Pres. R. S.*

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IN these papers I endeavour, to the utmost of my power, to distinguish between the facts which I am able to substantiate, and the hypothesis by which I have been directed in my inquiries. I hope that the importance of the facts may give some bias in favour of that mode of reasoning by which they have been discovered, and an additional interest to anatomical studies.

In my endeavour to arrange the nerves of the orbit, I encounter, in the first step, all the difficulties of my subject; for although there be only nine nerves properly enumerated as proceeding from the brain, six of these go to the eye; the second, third, fourth, part of the fifth, sixth, and seventh, go into the orbit, and may be said to be concentrated into a space no larger than a nut-shell.

In this investigation it is not always possible to give demonstrative evidence, or to answer opposition by cutting across a nerve; here we must proceed on a minute investigation of the anatomy, and by reasoning, rather than by experiment: yet I shall demonstrate what was stated hypothetically, in a former paper, that there is a correspondence between the compound functions of an organ, and the nerves transmitted to it.

Of the function of the ophthalmicus, a division of the fifth nerve.

We are, in the first place, to inquire by what nerve the common endowment of sensibility is bestowed upon the membranes and surfaces of the eye. On recurring to this subject we are reminded, that the sensibilities of the body differ as much in kind as in degree; that the sensation of pain is provided to rouse our activity, and guard us against violence, or, by means more direct, to excite instinctive motions, which shall anticipate the most rapid actions of the will, and serve as a more perfect safeguard. The trigeminus, or fifth nerve, bestows upon all the surfaces of the head and face, external and internal, that sensibility which is enjoyed by the rest of the body through the spinal nerves. But through some of its branches is also bestowed that distinct sense on certain parts, for the purpose of drawing the muscles into combination; as for example, that fine sensibility of the surface of the eye to the presence of minute particles, which at once excites the flow of tears, and draws the muscles into a combination to expel the offensive matter.

It has been shown in a preceding paper, by experiment, that on dividing the branch of the fifth nerve to the cheek and lips, the skin was deprived of sensibility, although in possession of other nerves, and enjoying muscular activity. The same has been proved in regard to this ophthalmic division; for if that branch of it which comes through the orbit and mounts upon the forehead, be divided, the skin will be deprived of sensibility.

These facts are so strong, that when supported by the symptoms of disease they afford no apology for deep dissec-

tion in the living animal, and authorize the conclusion, that all the branches of the same division resemble each other in function, and bestow sensibility on the parts within, as well as on those without.

That the ophthalmic nerve may be deprived of its function, and the parts supplied by it of their sensibility, we may learn from the following instance, communicated to me by Mr. CRAMPTON, of Dublin. To understand the inference from the following short narrative, it is only necessary to remember, that the nerve in question goes through the orbit, supplying the parts contained in it, but that it also extends its branches to the angle of the eye, eyelids, and forehead. "A few days after the discharge from the ear had ceased, the eye became entirely insensible to the touch. This loss of feeling extended to the lining of the eyelids, to the skin covering them, and to the skin of the cheek and forehead, for about an inch surrounding the eye: it did not go beyond the middle line of the face. When she told me her eye was *dead* (as she expressed it), to be certain, I drew my finger over its surface; and so far was this from giving her pain, that she assured me she could not feel that I was touching it at all. The eyelids made no effort to close while I was doing this, but the conjunctiva appeared sensible to the stimulus, as a number of vessels on the surface of the eye became immediately injected with blood."

Here we have an insensibility of the eye itself corresponding with the insensibility of the skin, which latter part we know possesses sensibility through the *fifth nerve;* and we therefore conclude, that it is the affection of the same nerve near its root, to which we have to attribute the insensibility

of the surfaces of the eye, as well as of the skin around the eye.

By experiment it can farther be made evident, that the sensibility of the eye enjoyed through the ophthalmic nerve, does not bestow on the organ directly, the power of combining the muscles, either for the defence of the eye, or for any other purpose. The impression must be referred back to the brain, and the muscles excited by their proper nerves. I have not been able to excite the motion of the eye by irritating the ophthalmic division of the fifth after the division of its root,* and in the instance just given, the eyelids did not move when the surface of the eye was irritated, because no sensation was conveyed inward to the sensorium, and consequently no mandate transmitted from it. The young lady could see, and could move the eye and eyelids; the eye itself was irritated by touch, as appeared from the rising inflammation; but by the insensibility of the ophthalmic nerve, a link was lost in the relation necessary to join the action of the muscles to the sensibility of the surface.

Of the nerves performing the involuntary motions.

We have just seen that nerves in great profusion come out upon the eyelids and forehead, and until these experiments were made, it was supposed that they directed the motions of the forehead and eyelids. But I have found that they have nothing to do with this function. On the contrary, a very small branch of the respiratory nerve of the face, that nerve which comes out before the ear, controuls the motions of the

* In attempting to excite the muscles of the eye by galvanism sent through the fifth nerve, the muscles of the jaw were affected.

forehead and eyelids. If this small nerve be divided, then the motions of the eyelids are lost, and they remain open. The inquiries instituted in the first part of this paper, give a lively idea of the consequences of this imperfection; showing that the eye being unguarded and unwashed, becomes dry by evaporation and inflames, and the cornea becomes opaque. It is unnecessary to point out the importance of this fact to the operating surgeon.

It has been asked, why should this nerve be called respiratory; and what have the actions of respiration to do with the eye-lids? The name was given to excite attention to certain relations; that the question might be asked, and the connections of remote parts noticed and remembered. These connections of remote parts are so curious, the knowledge of them is sometimes so useful, and they are so immediately related to the present subject, that I may be permitted to explain them.

During the state of excitement of the respiratory organs, a very extensive consent of the muscular frame is necessary to bind together and support the textures, that they may bear the strain either during violent efforts of the body, or in coughing, sneezing, &c. We may take the act of sneezing, as a familiar example of the manner in which the eye is guarded during a sudden and violent act of expiration.

At the instant of this convulsive action of the respiratory muscles, a violent impulse is communicated to the head along the column of blood in the vessels of the head and neck. Every body is sensible of the eye flashing light, but the cause is mistaken; for it is supposed to be the impulse of blood forced into the eye; whereas it is the contraction of

the eyelids to counteract the force of the impulse, and to guard the delicate texture of the eye. If the eyelids be held open during the act of sneezing, no sensation of light will be experienced, because the contraction of the eyelids upon the eyeball is prevented.

Can we believe this action of the muscle of the eyelids in combination with the action of the respiratory muscles, to be an accidental connection? Is it not rather a provision to compress and support the vascular system of the eye, and to guard it against the violent rush of blood which attends certain acts of respiration? If we open the eyelids of a child to examine the eye while it is crying, and struggling with passion, by taking off the natural support from the eye, the blood at the same time being forced violently into the head by the act of respiration, we shall see the conjunctiva suddenly fill with blood, and the eyelid everted.

The respiratory nerve of the face performs two offices, one of which is voluntary, as in moving the cheeks and lips in speech; and the other involuntary, as in moving the nostrils in breathing during sleep or insensibility. In like manner that branch of the respiratory nerve which is prolonged to the eyelids performs a double office, contracting the eyelids by volition, and also producing those involuntary winking motions of the eyelids which disperse the tears, and preserve the lucid surface clear.*

* Having distinguished the functions of the fifth and seventh nerves, a question still remains, whether the different operations performed by any one of them, depend on the exercise of distinct filaments? I believe these filaments to be distinct nerves bound up together, and analogy would lead me to suppose them capable of distinct functions; but I cannot demonstrate this unless in the spinal nerves, where the roots are separate.

But it has been observed, in the First Part of this Paper, that the shutting of the eyelids is not the only part of this act of preservation, and that the motions of the eyelids are attended with a rolling of the eyeball. How is this relation between the eyelids and eyeball established? This leads to an examination of the fourth nerve.

The fourth nerve.

This is a fine nerve, which takes its origin from the brain, at a part remote from all the other nerves which run into the orbit. It threads the intricacies of the other nerves without touching them, and is entirely given to one muscle, the superior oblique. We may observe too, that this singularity prevails in all animals. What office can this nerve have in reference to this one muscle? Why is it's root, or source, different from the other nerves, from the nerve of vision, the nerve of common sensibility, and the nerve of voluntary motion? We now reflect, with increased interest, on the offices of the oblique muscles of the eye, observing that they perform an insensible rolling of the eyeball, and hold it in a state of suspension between them. We have seen that the effect of dividing the superior oblique was to cause the eye to roll more forcibly upwards; and if we suppose that the influence of the fourth nerve is, on certain occasions, to cause a relaxation of the muscle to which it goes, the eyeball must be then rolled upwards.*

* The nerves have been considered so generally as instruments for stimulating the muscles, without thought of their acting in the opposite capacity, that some additional illustration may be necessary here. Through the nerves is established the connection between the muscles, not only that connection by which muscles

The course of inquiry leads us, in the next place, to observe the vicinity of the root of this fourth nerve, to the origin of the respiratory of the face, and we find them arising from the same track of fibrous substance. The column of medullary matter which constitutes that part of the medulla oblongata from which the respiratory nerves arise, terminates upwards, or at its anterior extremity, just under the corpora quadrigemina, and there the fourth arises. Is it possible then, we say, that there can be any correspondence between the general act of respiration, and the rolling of the eye? Led thus to make the experiment, I was gratified to find it so easy to give the proof. On stopping the nostrils with the handkerchief, every effort to blow the nose will be attended by a rapid rising of the cornea under the upper eyelid. And on every occasion when the eyelids suffer contraction through the agency of the respiratory nerve of the face, as in sneezing, the eyeball is rolled upwards through the agency of the fourth nerve.

I might, perhaps, be satisfied with having made the observation of these two facts; first, that there is such a combi-

combine to one effort, but also that relation between the classes of muscles by which the one relaxes while the other contracts. I appended a weight to a tendon of an extensor muscle, which gently stretched it and drew out the muscle; and I found that the contraction of the opponent flexor was attended with a descent of the weight, which indicated the relaxation of the extensor. To establish this connection between two classes of muscles, whether they be grouped near together, as in the limbs, or scattered widely as the muscles of respiration, there must be particular and appropriate nerves to form this double bond, to cause them to conspire in relaxation as well as to combine in contraction. If such a relationship be established, through the distribution of nerves, between the muscles of the eyelids and the superior oblique muscle of the eyeball, the one will relax while the other contracts.

nation of the motions of the eyeball and eyelids as I have before noticed; and secondly, that the nerves which move the eyelids, and the nerve of the obliquus muscle of the eyeball, are associated at their roots; but I should not do full justice to this interesting subject, if I did not attempt something farther.

It is plain that we must consider the nerves and muscles of the eyelids in a double capacity, in their voluntary, and involuntary actions. In the first, the motions of the eyelids combine with the whole muscles of the eyeball, as we may perceive in the voluntary contractions and squeezing of the eye; but in the insensible and involuntary motions of the eyelids, there would be no sympathy with the muscles of the eyeball, and therefore no correspondence in the motion of these parts, without a nerve of the nature of the fourth; that is, a nerve which having diverged from the root of the respiratory nerves, takes its course to the oblique muscles. In one word, the connection of its root declares the office of this nerve.

The expression of the eye in passion, confirms the truth of this relation being established by a respiratory nerve, and consequently by a nerve of expression. In bodily pain, in agony of mind, and in all this class of passions, the eyes are raised and dragged, in conjunction with the changes to which the other features are subjected. If it be asked now, as it has been asked for some hundred years past, why the fourth nerve goes into the orbit, where there are so many nerves, why it is so distant in its origin from the other nerves, and why it sends off no twig or branch, but goes entirely to one muscle of the eye? The answer is, to provide for the insen-

sible and instinctive rolling of the eyeball; and to associate this motion of the eyeball with the winking motions of the eyelids; to establish a relation between the eye and the extended respiratory system: all tending to the security or preservation of the organ itself.

Of the voluntary nerves.

The voluntary nerves of the eye are the Third and Sixth. The third nerve arises from the crus cerebri, that track of medullary matter which gives off all the nerves purely of volition. It is given to the muscles of the eye generally, and to no part but muscles. For these reasons we retain the name *motor oculi*, given by WILLIS, although his reasons for calling it so were fanciful and unsatisfactory. The Fifth nerve, by its ophthalmic division, gives branches to the muscles of the eye, but not so profusely as to the surrounding parts; and not more than sufficient to give them sensibility in the degree possessed by muscular substance generally. Since the branches of this fifth nerve, transmitted to the muscles of the eyelids and forehead, do not minister in any degree to muscular action there, it would be unwarrantable to suppose that they served the purpose of giving action to the muscles within the orbit. For these reasons, I conceive the Third nerve to be that which gives volition to the muscles of the eye, and that it is, of all the nerves of the body, the most perfectly and directly under the power of the will.

The *sixth nerve* is called *abducens*, and *motor externus*. With regard to its origin and distribution, there is no obscurity in this nerve; it arises from the same track of medullary matter which gives rise to the motor nerves, and it is distributed to

a voluntary muscle, the *rectus externus*. In this respect it is like a subdivision of the Third, and without doubt it is a voluntary nerve; but there is a circumstance in its connection which I cannot explain. It receives a gross branch from the great visceral nerve called Sympathetic. This nerve, ascending through the base of the skull, unites with the Sixth nerve as it is entering the orbit. Some having proceeded so far, would be inclined to call this an accidental connection, and so leave it; but similar investigations for many years have brought me to the conviction that there is no accident in an animal body; and Comparative Anatomy proves this to be a regular established relation.

To return to the consideration of these nerves of volition as they regard the eye, we may affirm, that although they want sensibility in the common acceptation of the term, they no doubt furnish the mind with the rudiments of certain sensations, and so far resemble the nerves of the senses. From experiments narrated in the first part of this paper, it appears, that we are sensible to the degree of agency exercised by the voluntary muscles of the eye. These nerves, the Third and Sixth, although they receive no external impression, are nevertheless agents which give rise to the perceptions of place or relation, in aid of that sensibility enjoyed by the optic nerve and retina.

I hope I have now unravelled the intricacy of the nerves of the head, and have correctly assigned to each nerve its proper office. In our books of Anatomy, the nerves are numbered according to the method of WILLIS, an arrange-

ment which was made in ignorance of the distinct functions of the nerves, and merely in correspondence with the order of succession in which they appear on dissection.

The first nerve is provided with a sensibility to effluvia, and is properly called olfactory nerve.

The second is the optic nerve, and all impressions upon it excite only sensations of light.

The third nerve goes to the muscles of the eye solely, and is a voluntary nerve by which the eye is directed to objects.

The fourth nerve performs the insensible traversing motions of the eyeball. It combines the motions of the eyeball and eyelids, and connects the eye with the respiratory system.

The fifth is the universal nerve of sensation to the head and face, to the skin, to the surfaces of the eye, the cavities of the nose, the mouth and tongue.*

The sixth nerve is a muscular and voluntary nerve of the eye.

The seventh is the auditory nerve, and the division of it, called *portio dura*, is the motor nerve of the face and eyelids, and the respiratory nerve, and that on which the expression of the face depends.

* In this view of the fifth nerve, I have not touched upon its resemblance to the spinal nerves. But if we had ascended from the consideration of the spinal nerves to the nerves of the head, we should then have seen that the fifth was the spinal nerve of the head; that it had a ganglion at its root, a double origin, and from its power over the muscles of the jaws and mastication, that it was a double nerve in function, being that nerve which bestows sensibility, at the same time that it sends branches to the original muscles; that is to say, to that class of muscles which are common to animals in every gradation. In all these respects it resembles the spinal nerves.

The eighth, and the Accessory nerve, are respiratory nerves.

The ninth nerve is the motor of the tongue.

The tenth is the first of the spinal nerves; it has a double root and a double office; it is both a muscular and a sensitive nerve.

Had I taken the nerves of any other complex organ rather than of the eye, I should have had an easier task. If I had taken the nerves of the tongue, I should have been able to prove by experiment, and in a manner the most direct, that the three nerves belong to three distinct functions, and stand related to three different classes of parts. I could have shown that taste and sensibility belong to the office of the fifth nerve, voluntary motion to the ninth, and deglutition to the glosso-pharyngeal nerve of the tongue.

In concluding these papers, I hope I may be permitted to offer a few words in favour of anatomy, as a means better adapted for discovery than experiment. The question lies between observation and experiment, and it may be illustrated by astronomy and chemisty. In the first, the objects being beyond the influence of man, he makes observations, not experiments; and the science at length attains a state of perfection which raises our estimate of the human intellect. In the latter, for the most part, the subjects lie out of the sphere of mutual influence; they must be brought together by artifice, and chemistry becomes a science of experiment. But anatomy is more allied to the former than to the latter

science, in as much as things are obvious to the eyes. In the animal body the parts present distinct textures, and are laid in a natural and perfect order; it is necessary only to trace the tubes, or to observe the symmetrical order of the nervous cords, in order to discover their respective uses: the motions, whether of the solid or fluid parts, are so regular and uniform, that the whole offers a subject for observation and induction. Anatomy is already looked upon with prejudice by the thoughtless and ignorant: let not its professors unnecessarily incur the censures of the humane. Experiments have never been the means of discovery; and a survey of what has been attempted of late years in physiology, will prove that the opening of living animals has done more to perpetuate error, than to confirm the just views taken from the study of anatomy and natural motions.

In a foreign review of my former papers, the results have been considered as a farther proof in favour of experiments. They are, on the contrary, deductions from anatomy; and I have had recourse to experiments, not to form my own opinions, but to impress them upon others. It must be my apology, that my utmost efforts of persuasion were lost, while I urged my statement on the grounds of anatomy. I have made few experiments; they have been simple, and easily performed; and I hope are decisive.

If we turn to the opinions which have been entertained on the subject of the brain and nerves, we find one theory to have prevailed from the Greek authors to the time of WILLIS, and to have descended from him with little alteration, to modern writers. The brain has been supposed to secrete and supply a nervous fluid, and the nerves to be the conduit

pipes for its conveyance. In every age the brain has been considered a common sensorium, and all the nerves to be capable of conveying sensation, unless when they had ganglia. If ganglia intervened, then the nerves were said to be cut off from the brain; and those so distinguished were called vital nerves, neither serving the purpose of governing the muscles, nor of conveying sensation. With all this apparent simplicity of doctrine, there never has been presented such a crude heap of errors, in the history of any department of science.

These notions were obviously founded on the mistake, that the same nerve served different purposes, and that a fluid moved in the same tube outwards to stimulate the muscles, and inwards to convey sensation of external impressions. So inconsistent are those opinions with the structure of the frame, that the simplest dissection proves them false.

So far is it from being true that ganglia cut off sensation, that I have ascertained, and proved by experiment, that all the nerves, without a single exception, which bestow sensibility from the top of the head to the toe, have ganglia on their roots; and those which have no ganglia are not nerves of sensation, but are for the purpose of ordering the muscular frame.

The hypothesis, that the nervous fluid streams out from the great officina along the nerves, has had an unfortunate influence in directing the labours of the experimentalists. During the last age it kept the pupils of HALLER engaged in inquiries regarding the influence of the nerves: *de nutritione imprimis nervosa:* and *de nervorum in arterias imperio;* and the interest of this question has not subsided, but, on the contrary, has encreased among us.

This notion of a fluid moving backwards and forwards in the tubes of the nerves, equally adapted to produce motion and sensation, has perpetuated the error, that the different nerves of sensation are appropriated to their offices by the texture of their extremities, "that there exists a certain relation between the softness of the nervous extremities, and the nature of the bodies which produce an impression on them." On the contrary, every nerve of sense is limited in its exercise, and can minister to certain perceptions only. Whatever may be the nature of the impulse communicated to a nerve, pressure, vibration, heat, electricity, the perception excited in the mind will have reference to the organ exercised, not to the impression made upon it. Fire will not give the sensation of heat to any nerve but that appropriated to the surface. However delicate the retina be, it does not feel like the skin. The point which pricks the skin being thrust against the retina, will cause a spark of fire or a flash of light. The tongue enjoys two senses, touch and taste; but by selecting the extremity of a particular nerve, or what is the same thing, a particular papilla, we can exercise either the one or the other sense separately. If we press a needle against a nerve of touch, we shall feel the sharpness, and know the part of the tongue in contact with the point; but if we touch a nerve of taste, we shall have no perception of form or of place, we shall experience a metallic taste.

The innovations of the celebrated continental authority BICHAT, did not bring us a step nearer the truth. When he at once threw off respect for his contemporaries, and for the authority of those who had preceded him, he equally disregarded the facts of anatomy. There may be merit in taking

new views of a subject, but BICHAT was continually holding a thing up by the wrong end, and presenting it in an aspect so singular, as to puzzle any one to say whether or not it was that with which he had been long familiar; accordingly, what had been termed the sympathetic system of nerves, he called the ganglionic system; although they are not more distinguishable by ganglia than the other nerves, upon which indeed the ganglia are remarkable for their size, number, and regularity. These ganglia must not be thrown out of the system altogether, merely because they are contained within the skull and vertebræ, which circumstance should rather mark their importance.

BICHAT persuaded himself that his ganglionic system was isolated, and a thing by itself; when, on the contrary, the connections of this part of the nervous system are universal. The wide spreading fifth pair, and the thirty spinal nerves, give large and conspicuous roots to this system. It exhibits a tissue extending universally.

It was a still more unfortunate mistake of this ingenious physiologist, to suppose the sympathetic nerve to be the same with that, which in the lower animals (the vermes), is seen coursing from one extremity of the body to the other. In the leech, or worm, those nerves produce union and concatenation of all the voluntary motions, and bestow sensibility as well as motion; yet he saw in the sympathetic system of the human body, only the developement of the same system of nerves, although he was aware that in man the sympathetic nerve bestowed neither sensibility nor the power of motion.

BICHAT announced his system with a popular eloquence, which had a very remarkable influence over all Europe.

Physiologists yielding to him, mistook the importance of the several parts of the nervous system; and even the multiplied experiments of LE GALLOIS failed to convince them of the nature of the spinal marrow.

The experiments of M. LE GALLOIS were of the rudest kind possible. The spinal marrow was cut across, or destroyed, by passing skewers into the spinal canal, and the effects were observed; as if the spinal marrow were a simple body. Whereas, by such destruction of its substance, the original ganglia, which form a series along the spine, must have been hurt; the track of nervous matter which gives rise to the nerves of sensation: that also which gives roots to the nerves of voluntary motion: and the lateral column connected with the offices of respiration, must all have been destroyed by such coarse experiments. It cannot surprise us that the results were obscure and contradictory.

But the most extravagant departure from all the legitimate modes of reasoning, although still under the colour of anatomical investigation, is the system of Dr. GALL. It is sufficient to say, that without comprehending the grand divisions of the nervous system, without a notion of the distinct properties of the individual nerves, or having made any distinction of the columns of the spinal marrow, without even having ascertained the difference of cerebrum and cerebellum, GALL proceeded to describe the brain as composed of many particular and independent organs, and to assign to each the residence of some special faculty.

When the popularity of these doctrines is considered, it may easily be conceived how difficult it has been, during their successive importations, to keep my Pupils to the examples

of our own great Countrymen. Surely it is time that the schools of this kingdom should be distinguished from those of France. Let physiologists of that country borrow from us, and follow up our opinions by experiments,* but let us continue to build that structure which has been commenced in the labours of the MONROS and HUNTERS.

The whole history of medical literature proves, that no solid or permanent advantage is to be gained, either to medical or general science, by physiological experiments unconnected with anatomy. To disregard the anatomy of the nervous system, or to take it in the gross; to make a new science *of life;* and influenced by a false analogy to call it a fluid; to attempt to direct it along a cord or a wire, is to transgress all the rules of philosophical enquiry, and must be attended with the rapid decline of anatomical studies. They will be considered as imposing restraints on genius, or be rejected as useless; and with them pathology, and all that is most necessary to medical science, will fall into disuse.

* See the experiments of M. MAGENDIE on the distinctions in the roots of the spinal nerves.