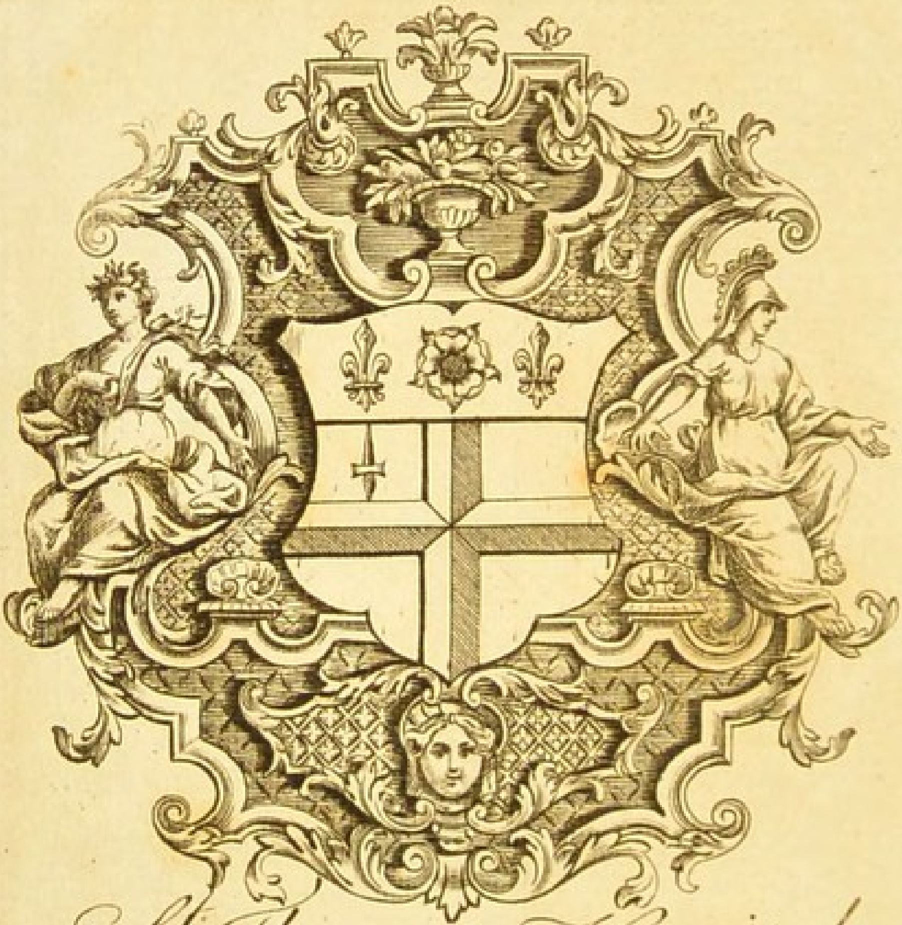

THE

PRACTICAL ANATOMY

AND

ELEMENTARY PHYSIOLOGY

OF THE

NERVOUS SYSTEM;

DESIGNED FOR THE USE OF

STUDENTS IN THE DISSECTING-ROOM.

BY

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The study of Anatomy, as it leads to the knowledge of nature and the art of healing, needs not many tedious descriptions: what is most worth knowing is soonest learned, and least the subject of disputes; while dividing and describing the parts, more than the knowledge of their uses requires, perplexes the learner, and makes the science dry and difficult.—*Cheselden.*

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PREFACE.

THE author has but few words to say in preface. The object of the present work is sufficiently indicated by the title; it is intended as a manual for the dissecting-room, the design having been to combine an accurate description of parts with the deduction of such practical hints as are deemed of sufficient importance to be useful to the surgical student. The idea of writing the work had its origin in the consideration that such a manual was a desideratum. In the design and manner of execution, the author lays claim to no attempt at originality: he has, moreover, the satisfaction of feeling that he cannot be fairly charged with arrogating to himself the opinions of others, since he has made a point of acknowledging his authorities, whenever any statements which he has not verified by his own dissections have required it.

The references to anatomical authorities are *frequent*, but principally *confined* to a few standard works; *frequent*, because the desire is to give the student the best and most accurate information, which object, the author conceives, will be better answered when statements are sanctioned by the high reputation of the authorities he quotes, than by the experience drawn from his own comparatively limited dissections: *confined to narrow limits*, because it is wished that every student should have the means of referring, for his own satisfaction, to the authors quoted. Bell's Anatomy, Swan's quarto edition of the Nerves, and Knox's translation of Cloquet's Anatomy, are works which are within the reach of every anatomical student, and are those to which reference is most frequently made.

The author does not pretend to indifference about the success of his publication; and, as some apology may be deemed necessary for adding one more to the long list of 'Anatomical Manuals,' he trusts (what he feels to be his due,) that his undertaking may be ascribed to motives which are far removed from a hope of notoriety, or the idle gratification of vanity. He felt the want of some assistance to draw his attention to practical points during his own early dissections of the nerves; and he is deeply impressed with the importance of combining the study of physiology with anatomy, a point much neglected in the dissecting-room: should he fail in his desire to supply, in some measure, this desideratum by the present manual, he will have to regret, in common with most unsuccessful authors, that his ability was not equal to his wishes.

One word with respect to the comparatively recent discoveries and novel opinions adopted in the present volume. Some little space has been devoted, in the physiological section, to a description of the 'Excito-motory system' of Dr. Marshall Hall,—not because the subject is novel, but from a firm conviction of the truth of the principles it involves, and the increased practical interest with which it clothes many hitherto obscure pathological conditions of the nervous system. The further opinions of Dr. Hall, respecting the external ganglionic nerves being nerves of nutrition, have not been adopted, for this reason,—that during the progress of the present work, the author still felt firmly convinced of the universal distribution and pervasion of the sympathetic or internal ganglionic nerves, as the agents of nutrition, &c.; but he is free to confess that his opinions have latterly become somewhat shaken, for reasons which will be given, either in the text or notes.

For Dr. Hall's liberality and kindness, in affording him information, the author begs to offer this public acknowledgment, and to express his admiration of talents which have been so successfully devoted by that gentleman to the cultivation of physiology as well as medicine.

In conclusion, it may be stated, that all useless detail and tedious repetition have been as much as possible avoided, in order that the descriptions might have a more decidedly practical tendency. For any omissions and inaccuracies, the author has to solicit all just indulgence, in the hope that they may not be such as materially to mislead the student in his dissections.

St. Thomas's Hospital,
July 12*th,* 1836.

INTRODUCTION.

UNTIL a period of comparatively late date, the investigations of physiologists had done little towards even arranging the nervous system, or assigning to the various parts of it their several uses. The dissections and experiments of modern anatomists, amongst whom our own country can boast of no mean share, have led to deductions and resulting discoveries of the most important character, in this interesting department of anatomy and physiology.

Much, however, as our information on this branch of the science has been extended, the student must bear in mind that a great deal of our knowledge respecting the functions of different parts of the nervous system, still rests on the unstable foundation of conjecture only. Physiology has not failed to suffer in common with science generally, from that most unphilosophical mode of proceeding by first building up the theory, and then *selecting* facts to support it: prejudiced experiments can only lead to partial or false conclusions.

Of the brain perhaps less is known than of any portion of the nervous system. Anatomy scarcely aids us; and the evidences of pathology are often even contradictory. That the source of common sensibility is itself insensible to the touch seems paradoxical: and that at one time the irritation of the brain produced by a minute spiculum of bone should be followed by perhaps fatal effects, whilst at another, "extensive lesions of the same organ may be unattended by severe or indeed any cerebral symptoms," is no less true than inexplicable. It required but brief experience to become acquainted with the fact, that continuity between the extremity of a nerve and the brain is indispensable to the performance of the function of the former; yet we are still in the dark as to the subtle medium of which the nervous cords are but the conductors.

The discoveries of Sir Charles Bell have formed one of the most remarkable features in the progress of our knowledge of the functions of nerves: most of the opinions promulgated by this physiologist are now sufficiently admitted, to be treated of, in a manual like the present, as established truths.

When the student peruses the scanty physiological observations which are interspersed in the following pages, he is requested to keep in mind the preceding remarks: and if he find the scattered hints sufficient to stimulate him to further study, the object in view will have been fully answered.

With respect to the practical remarks promised, they will apply and be confined to the injuries which nerves may receive by accidents or operations: and these, combined with occasional notices of the more important relative anatomy of regions, will, it is trusted, not prove useless. It were needless, after this, to say that there is no intention of entering on the general pathology of the nerves. It is a subject of itself, and quite incompatible with a work like the present.

Lastly, it is hoped that the student will derive some assistance from the reviews and short recapitulations of the more intricate parts that he will meet with in the course of his dissections; and from the tables which he will find attached to the different plexus and cerebral nerves[1].

[1] Previous to commencing the study of this branch of anatomy, let me warn the student against yielding too early to the desire of being *very accurate* in the more minute detail of various parts of the nervous system; I mean such detail as can have no evident points of either practical or physiological importance connected with it: for, let him be assured, such a course will most materially interfere with his acquiring a useful knowledge of his subject. Nor am I speaking at random; for every one who has been in the habit of attending much to the dissecting-room must have remarked the singular infatuation with which, in spite of all entreaty, some pupils will devote their whole time to unravelling and committing to memory a series of trifling points relative to the position of certain minute vessels and nerves, which it requires a great effort to retain, and which can, and will, never be turned to any useful account: and this all to the neglect of practical points of the first importance. Let the student, then, acquire first of all, what will stand him in good stead when he is practising his profession; and afterwards at his leisure he may become a more finished anatomist: for, however interesting much of the detail above alluded to may be, it is certainly not *essential* to the practitioner, and is very rarely retained except by those who are constantly dissecting. So true is the remark, that what is most useful is most easily acquired and remembered!

	Cerebral.			Excito-motory.		Sympathetic.		Page of reference to descrip-tion.
	Voluntary Motion.	Common Sensibility.	Specific Sensibility.	Excitor.	Motor.	Involuntary Motion.	Assimila-tion.	
Olfactory			*					135
Optic			*					138
Common Oculo-muscular	*				?			143
Pathetic	*				*			146
Trigeminal { ganglionic portion		*		*			?	147
Trigeminal { nonganglionic portion	*				*			159
Abducent	*				*			169
Facial	*				*			173
Auditory			*					181
Glosso-pharyngeal			* ?					185
Pneumo-gastric	*			*	*		?	188
Spinal accessory	*				*			212
Lingual motor	*				*			215
Cervical Plexus	*	*		*	*		?	235
Axillary Plexus	*	*		*	*		?	247
Dorsal Nerves	*	*		*	*		?	274
Lumbar Plexus	*	*		*	*		?	284
Sciatic Plexus	*	*		*	*		?	298
Facial Ganglia						*	*	330
Cervical Ganglia						*	*	337
Thoracic Ganglia						*	*	345
Abdominal Ganglia						*	*	348
Pelvic Ganglia						*	*	354

"Cerebral"—comprises those nerves whose functions are referable to the brain as their source.

"Excito-motory"—comprises those nerves which have for their centre or axis the true spinal marrow.

"Sympathetic"—includes the nerves which have their origin from, and their centres in, the several ganglia called *sympathetic*.

For the subdivision of the plexus and reference to the descriptions, the reader has to regard the last column.

* signifies that the nerve in whose line it appears belongs to the column to which it refers.

? signifies doubtful. All these signs under the column-head "Assimilation" are classed by Dr. Marshall Hall as belonging to the *external nutrient system*.

It is still questionable whether the glosso-pharyngeal nerve, or the lingual branch of the fifth, is the gustatory nerve.

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NERVOUS SYSTEM.

PART I.

THE BRAIN AND SPINAL CORD.

SECTION I.

THE whole nervous mass is comprised under two great heads, the Cerebro-spinal, and Sympathetic systems: each division possessing, apparently, different properties, performing different functions, and presiding over the various organs of the body for distinct purposes; combined, however, by their free communications with each other, into a cooperating whole.

The cerebro-spinal system consists of the common centre of perception and volition, viz., the brain, and spinal marrow with the various cords, called nerves, derived from this common centre. The sympathetic system is similarly divisible; the common centre, however, in this system, consisting of numerous small and scattered nervous masses, called ganglia[1].

The student's attention will be first directed to the encephalon, of which the first Part of this Manual will consist; and the order pursued will be to describe, first, the brain and spinal cord, and subsequently the cerebral and spinal nerves.

THE BRAIN[2].

The calvarium having been removed by the saw, the dura mater may be divided with a pair of scissors in a circle corresponding to the section through the bone. Considerable care is then required in removing the brain: the anterior part should be gently raised, and the carotid arteries and several nerves divided with the scissors as near to the bone as possible; and the pituitary body should be removed from the sella turcica by cutting through the investing dura

Mode of removing the brain.

[1] A further system will be treated of in the Physiological Part; but of this nothing will be at present said.

[2] In studying the anatomy of the brain, the student is warned against yielding to the feeling of distaste which may accompany the detail of various parts comparatively destitute of practical interest. He must remember, that without a previous knowledge of the normal or healthy appearance of this organ, he can never hope to detect the effects of disease; and that it is to pathology in particular that we must look for the advancement of our physiological knowledge in this department of anatomy.

mater. The cerebellum should be liberated by carefully dividing the tentorium on either side; and lastly, the medulla oblongata should be divided as low down in the spinal canal as a long knife can reach. The two longitudinal and the straight sinuses will be removed with the dura mater attached to the brain; the rest may be examined in the skull.

MEMBRANES OF THE BRAIN.

The membranous coverings of the brain are three: the dura mater, or supporting membrane; the arachnoid, or serous membrane; the pia mater, or vascular membrane.

DURA MATER.

The dura mater is the external of the three membranes; it is firm, tough, thick, slightly translucent; and insensible, as proved by the experiments of Haller and others. It is made up Structure. of glistening fibres taking different directions; and is partially adherent, especially where ossification is incomplete, to the vault of the skull, by means of its own fibres and transmitted blood-vessels; this accounts for the flocculent and blood-dotted appearance of its exterior. Its internal surface is smooth, lubricated and pearly; this is owing to the adherent layer of the serous membrane. The adhesion of the dura mater along the sutures is remarkable; it is caused by actual continuity of this membrane with the external pericranium, which is best seen in the young skull that has been macerated for a short time[1].

The dura mater is adherent to the whole base of the skull: there are, however, certain points at which the connexion is more intimate; these require a brief notice previous to the description of the folds of this membrane.

Connexions.

It is firmly attached to the foramen cæcum and crista galli of the æthmoid bone; to the transverse spinous processes and sella turcica of the sphenoid bone.

Processes.

Every aperture in the base of the skull is lined by dura mater; we may enumerate the following: *processes* accompany the filaments of the olfactory nerve through the crebriform plate of the æthmoid bone: the dense process around each optic nerve may be traced, after some connexion to the orbitar periosteum, into the sclerotic, though it cannot be said that this tunic is formed by it: the processes entering

[1] In early life, the two membranes are in apposition, and the radiating ossific fibres shoot in between them; this may be readily examined in the fœtal or young skull. A short time since, I removed, in the dissecting-room, a portion of the calvarium of an individual who had evidently been the subject of a sabre-wound of the head at some distant period, by which a portion of bone had been sliced off. A fresh layer of periosteum had been produced, and become adherent to the dura mater, the squamous edges of the bone being for a certain distance interposed, as before ossification is completed.

the sphenoidal fissures form the periosteum of the orbitar cavities: those portions of the membrane surrounding the two inferior divisions of the fifth nerve, are continuous, by the foramina rotunda and ovalia, with the external periosteum; and this is also the case with the processes accompanying the eighth and ninth nerves[2]. The internal auditory foramina are likewise lined by this membrane; and apertures are found in it for the transmission of the carotid arteries. Lastly, the dura mater accompanies the cord into the spinal canal; of this, however, when the cord is described.

The *folds* of the dura mater are formed by the reflexion of this membrane at various parts of the skull, for the purpose of forming septa or partitions between different portions of the brain; thus aiding, in a remarkable manner, in the support of this tender organ; and answering another important end, by preserving from pressure the veins contained between their layers. These folds are the following[3]. Folds.

[2] It will thus be remarked, that the nerves are not dependent on this membrane for their neurilema.

[3] By some authors the dura mater is described as consisting of two layers, (*i. e.* independent of the adherent arachnoid;) the external forming the cranial periosteum and sheaths of the nerves; the internal, the different processes. Certain it is, that this membrane splits to inclose the venous membrane and form the sinuses; for example, the superior longitudinal sinus is thus formed; the internal layer of the dura mater of one

Falx major. *Falx Cerebri* is the longitudinal partition extending from the crista galli along the sagittal suture, and terminating at the crucial ridge of the occipital bone: it has been not inaptly described as resembling the blade of a sickle: it is broad posteriorly, gradually narrowing as it extends forwards: it forms the septum between the two hemispheres of the cerebrum. In its superior border is contained the superior longitudinal sinus; in its free or concave margin we find the inferior longitudinal sinus. This falx is occasionally perforated by foramina, particularly near its free border; and instances have been met with where it has been totally wanting: these are very rare[1].

Tentorium. *Tentorium* is the transverse partition extended between the posterior lobes of the cerebrum which it supports, and the cerebellum which it covers. It is derived in the central line from the great falx, and as it stretches laterally, becomes attached on each side to either margin of the transverse grooves of the occipital bone, crossing the inferior angle of the parietal, and connected along the superior border of the petrous portions

side converging towards that of the opposite, they form by their union the inclined walls of the sinus; its roof being the uninterrupted external layer: further than this, I cannot see the object of dividing this membrane into two fibrous layers; a separation which cannot be effected except in shreds.

[1] Noticed by Sir Charles Bell, Anatomy, vol. ii. p. 417.

of the temporal bones: it terminates anteriorly by stretching between the clinoid processes of the sphenoid. Its concavity corresponds to the pons Varolii and crura cerebri. Along its margin of attachment the lateral and superior petrous sinuses are found; and in the central line, between it and the falx, the straight sinus extends.

Falx Cerebelli is in the same line with the great falx; stretching between the tentorium and occipital foramen, and separating the hemispheres of the cerebellum. In its convexity are contained the occipital sinuses. Falx minor.

Sphenoidal folds are attached to the small wings of the sphenoid bone, and correspond to the fissures of Sylvius. Sphenoidal folds.

Remarks. The dura mater not only answers the purpose of a supporting membrane to the brain, but also has a highly important function to perform as the internal periosteum of the skull. The large arteries it incloses, derived from so many sources as enumerated below, are evidently destined in great measure for the supply of the bone; and this accounts for the fact, that destruction of the pericranium does not necessarily imply a consequent exfoliation of bone, which almost uniformly follows separation of the dura mater from the internal table[2].

[2] See Harrison's Surgical Anatomy of the Arteries, vol. i. p. 66.

Vessels. *Organization.* The meningeal arteries are derived from the internal carotid and ophthalmic; the internal maxillary and ascending pharyngeal; the occipital, vertebral and posterior aural. The middle meningeal from the internal maxillary is the largest. These vessels have also to supply the adherent layer of arachnoid membrane.

Nerves, &c. It has been stated that the dura mater is insensible; but Professor Arnold has demonstrated that it is supplied from other sources than the sympathetic filaments accompanying the arteries, which alone had, previous to this, been satisfactorily demonstrated[1]. This membrane of course possesses lymphatics, though they have not been traced. Its veins terminate in the sinuses, principally in the superior longitudinal.

SINUSES.

The *Sinuses* are certain canals, arranged symmetrically between folds of the dura mater, and lined internally by the common lining membrane of the venous system. They are probably at all times uniformly distended and perfectly inert; uninfluenced by and equally uninfluencing the motion of their contents: they are, in short, passive tubes through which the blood is transmitted from the brain to the great jugular veins.

[1] The recurrent branches of the first division of the fifth; to which the reader is referred.

Some of these sinuses are single, and some disposed in pairs; the total number being sixteen.

Azygos sinuses.		Pairs.
Superior longitudinal.		Lateral.
Inferior ditto.		Superior petrosal.
Straight.		Inferior ditto.
Transverse.		Cavernous.
Circular.		Occipital.
Torcular Herophili.		

We shall describe them in the order that will render them most easily understood.

Torcular.

Torcular Herophili is placed opposite the internal occipital protuberance, at the junction of the falx with the tentorium. Its form is irregular, and it is the central cavity into which the following two pairs, and two single sinuses open; superior longitudinal, straight; two lateral, two occipital[2].

Superior Longitudinal sinus, triangular, commences narrow by a cul-de-sac at the foramen cæcum[3]; passes back, gradually increasing in dimension, and terminates by a triangular opening in the superior part of the torcular Herophili. Its course corresponds to the whole extent of the falx cerebri; and the groove for it in the bone is usually continuous with the *right* lateral groove. This sinus receives small veins from the exterior

[2] This cavity with its openings is best exposed by breaking through the bone externally, which is readily effected in the young subject.

[3] It sometimes commences by a small vein received from the nose.

of the skull, which pass in by the sagittal suture and parietal foramina; also small branches from the dura mater: but the great veins which empty their blood into it, are those from the surface of the brain itself. These veins, about ten or twelve on either side, are not exactly symmetrical, and their mode of terminating in the sinus certainly irregular: they are nearly uniformly inclined backwards as they run along the surface of the hemispheres, and do not confine themselves to the sulci: previous to joining the sinus they incline forwards, piercing it obliquely in this direction, and consequently contrary to the course of the blood; this, however, is not invariably the case, as noticed by Ridley, Bell, and others; I have remarked that the axes of some of the venous orifices have been at right angles with the sinus.

Glandulæ Pacchioni.

On the dura mater, and principally in the course of this sinus, there are certain little granular bodies scattered: patches of a similar granular nature are also met with on the investing arachnoid membrane, near the terminations of the veins last described, and not infrequently on the base of the brain: these, together with small bodies, not dissimilar in appearance, found within the superior longitudinal sinus, have been indiscriminately described under the name of *Glandulæ Pacchioni.* Whatever may be the nature of these bodies, and it is highly probable they are none of them glandular, it is clear that the use of those within and without the sinus must be different. It is one opinion that the internal granules, which are principally clustered about the orifices of the veins, perform the action of valves to the mouths of the vessels, preventing regurgitation of the blood[1]; to the external it is difficult to assign a use. The *Chordæ Willisii,* which are found tra- Chordæ. versing the great longitudinal sinus at different points in a transverse direction, serve an evident purpose in guarding against the possibility of undue distention: these are fibrous bands surrounded by the venous membrane.

Inferior Longitudinal sinus, contained in the concave margin of the falx major, terminates posteriorly in the straight sinus, receiving small veins from the falx and corpus callosum; it is sometimes wanting, and indeed generally very small.

Straight sinus corresponds to the base of the falx, and extends from the last-described to the torcular Herophili: the venæ Galeni, and branches from the cerebellum terminate in it. This sinus possesses fibrous bands similar to the chordæ Willisii.

Occipital sinuses converge from the margin of the foramen magnum, and usually unite in the falx minor, and terminate in the torcular Herophili. These are sometimes wanting, and some-

[1] See Bell's Anatomy, vol. ii. p. 484.

times communicate with the lateral sinuses or vertebral veins.

Lateral sinuses are very large, and convey the blood which has been poured into the torcular Herophili to the jugular veins. Their course corresponds to the attachment of the tentorium, extending from the internal occipital protuberance to the posterior lacerated foramen of the skull: in this course they receive veins from the posterior part of the cerebrum, from the cerebellum and the tentorium, and communicate by the mastoid and posterior condyloid foramina with the occipital veins: they also receive the blood from the petrosal sinuses. The sinus of the right side is usually the larger.

Cavernous sinuses are placed on either side of the body of the sphenoid bone, each extending between the corresponding anterior clinoid process of this, and the point of the petrous portion of the temporal bone: it derives its name from the existence of intersecting fibrous bands which give it a cellular appearance. These sinuses receive the ophthalmic veins and some branches from the dura mater; and communicate with each other by the circular and transverse sinuses: their blood is transmitted to the great lateral by the petrosal sinuses. These are formed like the other sinuses by the splitting of the dura mater, which also in part occupies the sphenoidal fissure. Along the inner surface of either the carotid artery is found, external to which is the sixth nerve, both separated from the blood by a reflection of the venous membrane; the third, fourth, and first division of the fifth nerves are contained in its outer wall.

Superior Petrosal sinuses extend from the cavernous back to the lateral sinus of either side; corresponding to the tentorium and superior margin of the petrous bone, and crossing above the fifth nerve.

Inferior Petrosal sinuses commence close to or in common with the last, but terminate lower down in the lateral sinus: they correspond to the line of apposition of the occipital and inferior margin of the petrous bone.

Transverse sinus crosses the basilar process from the point of junction of the cavernous and inferior petrosal sinuses of one side, to the same point on the opposite[1].

Circular sinus surrounds the pituitary body, passing beneath the optic commissure.

Remarks. There are points of considerable interest to the surgical anatomist, connected with the Sinuses: the most prominent may be considered under two heads; 1st, the probability of rupture from injury, &c.; 2nd, the fear of trephi- Practical remarks.

[1] Cloquet remarks, that it is by no means uncommon to find two or three transverse sinuses.

ning over them. The most likely accident to produce the former is fracture, particularly through the base of the skull; and we have cases on record similar to that related by Dr. Harrison, in which he found rupture of the cavernous sinus communicating with the tympanum: previous to death there had been bleeding from the ear; and the post-mortem examination proved that the base of the skull had been fractured through the petrous and mastoid portions of the temporal bone. Trephine. With respect to the application of the trephine over the superior longitudinal sinus, all our first authorities agree, that fatal or dangerous hæmorrhage rarely follows this operation, if proper precaution be taken. In the first place, it is not necessary to open the sinus, which is still protected from the trephine by its superior wall: and, in the second place, if the fracture be directly over the sagittal suture, the symptoms of compression may in part or wholly arise in consequence of blood being extravasated from the lacerated sinus: and lastly, even should the sinus be wounded during the operation, we are assured that a dossil of lint will command the bleeding. These remarks are equally applicable to the course of the middle meningeal artery. The delicacy of structure of this vessel, and its intimate connexion to the dura mater, preventing its retraction into surrounding tissues, are probably sufficient to account for the facility with which bleeding from this artery is arrested[1].

Course of blood.

A review of the sinuses and their communications will show that all the blood which circulates through them is ultimately collected in the great lateral sinuses, whence it is conveyed to the internal jugular veins: these vessels unite, opposite the sterno-clavicular articulation on either side, with the corresponding subclavian vein to form the venæ innominatæ; their junction on the right side of the ascending aorta receives the name of superior vena cava, which terminates in the posterior and upper part of the right auricle of the heart.

The free communication of the sinuses with one another, is of the highest importance in preventing the occurrence of pressure which would necessarily result from obstructed circulation. The lining membrane alone of the veins is continuous with the sinuses[2].

[1] See Cooper's Surgical Dictionary, article TREPHINE; where Larrey, Sharpe, and others are quoted. Also Bell's Surgery, vol. ii. p. 394.

[2] Every one who has seen the dura mater exposed, as in the operation of trephining, must have remarked its alternate elevation and depression, the former synchronous with expiration, the latter with inspiration. It seems natural that this membrane should collapse when the chest is dilated, and the sinuses are allowed to empty themselves freely into the jugular veins: but the question is, whether there be any motion whilst the cranial parietes are perfect.

ARACHNOID MEMBRANE.

This is the *serous* covering of the brain: it possesses all the properties characteristic of this class of membranes, viz. consisting of a reflected or double sac, having all the parts with which it is in contact external to it; containing alone the serous exhalation by which its interior is lubricated. The external or *parietal* layer is closely adapted and adherent to the dura mater and its several folds, except at the sella turcica, where the pituitary body is interposed. In like manner, the whole surface of the brain is closely invested by the *visceral* layer, which, however, does not penetrate into the sulci that separate the convolutions: the points of continuity of the parietal and visceral portions, are at the passage of vessels and nerves in and out of the skull, around each of which this membrane is reflected[1]. The cavities in the interior of the brain are moreover lined by a prolongation of this membrane. The external layer shall first be traced, and subsequently the internal division.

External layer.

General reflexion.

We will commence the description of the former in the median line along the concave margin of the falx cerebri. We find it passing upwards on either side of this partition, and thence ex-

[1] The student cannot fail to remark the close analogy that exists between the pericardium and fibro-serous portion of the membranes of the brain.

panded, from the walls of the longitudinal sinus, on either half of the vault of the skull, and posteriorly, on either surface of the tentorium; these portions meet in the base of the skull which is thus lined: a process is then sent down to line the theca vertebralis, and being subsequently reflected on the cord, is thus conducted to the brain[2]; and other processes are in like manner reflected at the exit of each nerve: in the base, after covering the medulla and pons Varolii, we find it conducted along its crura to the cerebellum, which is thus invested; in like manner is the inferior surface of the cerebrum covered, the membrane being thick in this situation, and stretched forwards from the pons to the optic commissure: it is then continued around the hemispheres, sinking into the great fissure, and lining the corpus callosum. The veins entering the different sinuses all form media by which the visceral and parietal portions of this membrane are rendered continuous.

The *internal* division of the arachnoid is that portion which lines the cavities of the brain, and bears a relation to the general cavity of this membrane, somewhat analogous to that borne by the great omental sac to the cavity of the peritoneum; in each case, the small bag communicating with

Internal prolongation.

[2] See 'Spinal Cord'; where will be found the description of the continuation of the cerebral membranes in the vertebral canal.

the larger by a contracted neck or aperture[1]. In the instance now before us, this aperture is the point of exit of the venæ Galeni, and is named the Canal of Bichat[2]. The position of this opening is between the posterior margin of the corpus callosum and the cerebellum, and it is here that the reflexion takes place. The venæ Galeni are at first contained within this canal, which is subsequently prolonged beneath them and the velum interpositum, and between the pineal body and tubercula quadrigemina, where it terminates in the third ventricle: the membrane then invests the plexus choroides, and passes with them into the lateral ventricles by the foramen commune anterius, and traverses the aquæduct of Sylvius to the fourth ventricle. Thus we find all the ventricles lined and their apertures closed[3].

Canal of Bichat.

Use.

Remarks.—The perfect lubrication of the opposed surfaces of this membrane renders it a tunic of the first importance to so tender an organ as the brain, even under the slight amount of motion to which it may be liable. Red vessels have never been observed in it, even when inflamed;

[1] In the instance of the peritoneum, the foramen is named after Winslow.

[2] Bichat first described this internal reflexion of the membrane: in his 'Descriptive Anatomy' a lengthened account of it will be found.

[3] This portion of the membrane cannot now be traced; but the student is requested to turn back to this description during his dissection of the brain.

but whiteness, opacity, increased thickness, effusion of serum or lymph, are the most common results of a morbid vascular action in this membrane.

PIA MATER.

This delicate membrane is in contact with the structure of the brain, and is named the *vascular* tunic. Its texture is cellular, and its adherence to the brain is dependent on the many blood-vessels which pass from the one to the other: it not only covers the surface, but dips into the interstices between the convolutions, which may be seen by raising the arachnoid, though these membranes cannot well be separated where they are in contact, on the convexity of the hemispheres. This tunic also passes into the interior of the brain, for which purpose there exists an extensive fissure, closed, however, by arachnoid membrane, except at Bichat's canal: in the centre, it is bounded above by the corpus callosum, below by the pons Varolii; on either side, it is found between the optic thalamus and hippocampus major. It is through the lateral part of this fissure that that portion of the membrane named *plexus choroides* enters the inferior cornu of the lateral ventricle, and passing to the foramen commune anterius, there unites with that of the opposite side. The central process of pia mater

Plexus choroides.

Velum. is called *velum interpositum*: posteriorly its margins are free; but anteriorly, continuous with the plexus of either side.

The pia mater descends with the cord into the vertebral canal (See 'Spinal Cord'); it moreover

Vessels. affords a covering to each nerve at its exit. The arrangement of the blood-vessels in it is intricate, and no doubt connected with its office to the brain. Under inflammation, it becomes highly injected and turgid.

STRUCTURE OF THE BRAIN.

The brain is composed of two substances, which differ in appearance and structure; the one grey or cineritious, the other white or medullary.

The *grey* matter is found principally disposed on the exterior of the brain, investing the medullary matter, and has therefore also received the

Distinctions of colour, &c. name of cortical substance. This disposition does not, however, invariably hold good; for the grey matter is also found in the interior of the brain, sometimes enveloped by the white matter, and sometimes intermixed with it, as will be noticed in the course of the dissection.

The intensity of *colour* of these substances also varies; but the two are in no part found blended into one another, the line of distinction being more or less abrupt: in dropsical subjects the grey colour is much less intense, and in some cases nearly lost[1].

As to *consistency*, the grey matter is pulpy and easily broken down; whilst the medullary substance is comparatively firm, and when fresh, even elastic and resisting, and consequently does not yield so soon to putrefaction. Cloquet remarks that the latter only loses six tenths of its weight by desiccation, whilst the former loses eight tenths.

The *structure* of these parts has been a subject of considerable dispute amongst physiologists; it appears, however, now to be a generally received opinion, that the medullary structure is fibrous, and the cineritious the more vascular of the two. It may be further added, that microscopic observation has apparently proved the globular nature of both structures[2].

[1] I think I never saw the general cineritious structure of the brain, and particularly of the cerebellum, of a deeper hue than in the case of a man who died of tetanus. The surface of the brain and cord were also highly injected, and many of the veins turgid.

[2] Bellingeri ventures an opinion, that to the cineritious structure appertains the property of sensation, and to the medullary matter that of motion. This opinion he deduces from certain facts stated in his work, with respect to the origin of the nerves of motion and sensation; and from the fact that the quantity of cineritious matter far exceeds the medullary in childhood, at which period there is most sensibility and least muscular development; in adults the converse is the case.—*C. F. Bellingeri, De Medullâ spinali Nervisque*, sect. ii. cap. iv.

The *size* of the brain differs in different individuals. It is proportionally much larger in the child than in the adult; its weight being, according to Cloquet, the sixth or seventh part of that of the whole body, at the moment of birth; but in the full-grown man not more than about the thirty-fifth part[1].

ANATOMICAL DIVISION OF THE BRAIN[2].

For the purpose of facilitating description, the

[1] Mr. Lawrence remarks, "Modern physiologists, in comparing the proportion which the mass of the brain bears to the whole body in man and other animals, have found that several mammalia, as the dolphin, seals, some quadrumana, and some animals of the mouse kind, equal the human subject, and that some small birds even exceed him in this respect...... Soemmerring has therefore furnished us with another point of comparison, viz. that of the ratio which the mass of the brain bears to the bulk of nerves arising from it. Let the brain be divided into two parts; that which is immediately connected with the sensorial extremities of the nerves, which receives their impressions, and is therefore devoted to those common wants and purposes which we partake with animals. The second division will include the rest of the brain, which may be considered as the seat of mental phænomena. In proportion, then, as any animal possesses a larger share of the latter and more noble part—that is, in proportion as the organ of reflexion exceeds that of the external senses—may we expect to find the powers of the mind more diversified and more fully developed. In this point of view, man is decidedly pre-eminent." Again: "The most striking character of the human brain is the prodigious development of the cerebral hemispheres, to which no animal, whatever ratio its whole encephalon may bear to its body, affords any parallel."—*Lawrence's Lectures on Physiology, &c.* 3rd edit. p. 165.

[2] In making a dissection of the brain, the student should

brain is considered as consisting of three parts, cerebrum, cerebellum, and pons Varolii: to these a fourth may be added, viz. the medulla oblongata; this, however, is only the commencement of the spinal cord, with which it is better described.

A superficial observation will suffice to show that this organ may be further divided throughout its whole longitudinal extent into two equal portions: now, as these halves are perfectly symmetrical[3], it is evident that the description of one side implies that of the other also.

CEREBRUM,—*external view.*

The cerebrum forms the principal mass of the brain; its superior surface is in contact with the vault of the skull, and consequently convex; whilst the inferior surface, resting upon the anterior and middle divisions of the base of the skull and the tentorium, is more irregular. From the shape of the skull, it results that the form of the cerebrum is oval, but broader behind than in front. The great longitudinal fissure which receives the falx cerebri will be seen stretching Hemispheres.

have placed before him one skull with the falx and tentorium dried *in situ*, and another perfect base. It may be well to remind him that the transverse spinous processes of the sphenoid bone anteriorly, and the superior angles of the petrous bones posteriorly, form the boundaries of the middle division of the base of the skull; which of course separates the anterior from the posterior divisions.

[3] With the exception, it may be remarked, of the form of the convolutions, which are seldom precisely alike on both sides.

from before backwards along its superior surface, dividing it into its two *hemispheres*; these are separate anteriorly and posteriorly, but connected in the centre by the corpus callosum or great commissure.

Surfaces.

We have to observe on the *superior* surface of either hemisphere, the convolutions (*gyri*), which are irregular in form, and variable in size and direction, and separated by deep fissures (*sulci*).

The *inferior* surface of the cerebrum requires a more careful inspection. Here the convolutions are less curved and contorted, and the sulci not half the depth of those on the superior surface: here, as well as above, we meet with the great longitudinal fissure anteriorly and posteriorly; but the separation of the middle portion of the hemispheres is only marked by the central depression.

Lobes.

Each hemisphere is subdivided into three *lobes*, which correspond to the two anterior divisions of the skull and the tentorium: the *anterior* lobe is slightly concave and rests on the arched roof of the orbit: the *middle* lobe is prominent and convex, resting in the deep middle fossa of the base of the skull, and separated from the anterior lobe by a well-marked fissure (*fissura Sylvii*), the direction of which is upwards outwards and backwards; this corresponds to the transverse spinous processes of the sphenoid bone, and the sphenoidal folds of the dura mater. The *posterior* lobe is that portion of the hemisphere which is supported by the tentorium: it is slightly hollowed, and its surface continuous with that of the middle; the nominal line of division corresponding to the anterior margin of the cerebellum.

We now come to notice the parts contained in the middle depression of the inferior surface of the cerebrum: for this purpose the arachnoid membrane should be carefully dissected away from the vessels and nerves, between the longitudinal fissure anteriorly, and the pons Varolii posteriorly; two large cylindrical bodies will then be observed emerging from the pons, and taking a direction forwards and outwards to terminate in the medullary interior of the cerebrum; these are the *crura cerebri*: crossing them at nearly a right angle, we find on either side a flat band of medullary matter, converging and assuming a cylindrical form as it approaches the anterior median fissure; these bands are the *tractus optici*, and their union the optic commissure. These parts will be found to inclose a *diamond-shaped space*, the angles of which are at the optic commissure, the pons Varolii, and the points whence the tractus and crura diverge from each other; the objects contained are the following: immediately behind the optic commissure, a grey tubercle with a medullary nucleus, the *tuber cinereum*; descending from it, a narrow, conical tube, the *infundibulum*; this terminates on the pitui- Diamond-shaped space.

tary body, but above will be found to communicate with the third ventricle: the *pituitary body* is lodged in the sella turcica; anteriorly it is firm, posteriorly pulpy, and its greatest diameter is from side to side; its nature and use are unknown: the *corpora mammillaria* are small pea-shaped tubercles placed behind the tuber cinereum; they are connected to each other, and consist of a grey nucleus, and medullary investment which is derived from the anterior pillars of the fornix: lastly, we have to observe between these and the pons the *locus perforatus*, a small triangular depression pierced by vessels; its structure is medullary, and it forms part of the floor of the third ventricle.

We may further remark in the middle line of the base of the brain, and before the optic commissure, the anterior extremity of the median fissure and of the corpus callosum; and behind the pons, the posterior extremity of the corpus callosum and fissure: the canal of Bichat, and great cerebral fissure for the transmission of the pia mater into the ventricles, may now also be seen between these two last-named bodies.

Previous to commencing the dissection of the cerebrum, the student may desire to be acquainted with the vessels he finds on the base of the brain; an enumeration of these will now be given, together with a short notice of the cerebral nerves as they appear on the base of the brain previous to dissection; though of course this last subject will be treated of at length in its proper place.

ARTERIES OF THE BRAIN.

The arteries which supply the brain are derived from two pairs of vessels, viz. the internal Carotids and the Vertebrals; they are the following: inferior and superior cerebellar arteries; posterior, middle, and anterior cerebral arteries; which with two lateral and one anterior communicating branch, complete the circle of Willis.

The vertebral arteries are seen ascending on the lateral and anterior part of the medulla oblongata, and at the constricted junction of this with the pons Varolii they unite into one trunk, which, taking the name of *basilar*, proceeds forwards along the raphe of the last-named body, to terminate by bifurcation at its superior margin.

Each internal carotid artery, after emerging from the cavernous sinus, becomes attached to the brain near the internal extremity of the fissure of Sylvius, where it divides into three branches[1].

Arterial branches.

The *inferior cerebellar* arteries arise usually from the vertebral, but sometimes from the basilar: they wind round the medulla oblongata, and are distributed to the inferior surface of the cerebellum[2].

[1] Which might with propriety be termed *the carotid axis*.

[2] These are not always symmetrical in their origin; sometimes one arises from the basilar, and that of the opposite side from the vertebral artery.

The *superior cerebellar* arteries arise from the basilar near its anterior bifurcation; they turn backwards and upwards, and supply the superior surface of the cerebellum.

As the basilar artery is traversing the *pons*, small transverse branches are given to this body.

The *posterior cerebral* arteries are the terminating branches of the basilar; they receive the lateral communicating branches from the carotids, and are distributed to the posterior lobes of the cerebrum.

The *lateral communicating* arteries arise from the carotids just after they leave the cavernous sinus; they converge as they pass backwards, and terminate by joining the posterior cerebral arteries.

The *anterior cerebral* arteries converge as they pass forwards above the optic nerves; and if the anterior cerebral lobes be carefully drawn asunder, it will be observed that these vessels communicate by a large but short transverse branch, the *anterior communicating* artery: the place of this artery is sometimes supplied by a direct union of the trunks, which again immediately bifurcate. These arteries, after bending round the anterior margin of the great commissure, run backwards along either side of its raphe, receiving, in that situation, the name of artery of the corpus callosum: they are distributed to either hemisphere.

The *middle cerebral* arteries take the course of the fissures of Sylvius; they are usually the largest of these branches, and supply both the anterior and middle lobes of the cerebrum.

Circle of Willis.

The arterial *circle of Willis* surrounds the diamond-shaped space already noticed in the base of the brain, and is formed thus: in front, by the anterior cerebral arteries and their communicating branch; laterally, by the carotids and lateral communicating branches; and behind, by the basilar and posterior cerebral arteries[1].

These capacious arteries and their free inosculation form a highly interesting subject of study, whether we view them in a practical or physiological light; combining, as they do, the double advantage of a large supply of blood, sufficient to nourish and produce the necessary exciting impression upon this important organ, and, at the same time, the means of obviating the occurrence of pressure from obstructed circulation[2].

[1] A short time since I remarked an instance in which this circle was incomplete. One of the lateral communicating branches was wanting; a small twig, which was distributed to the substance of the brain, supplied its place, and the calibre of the corresponding artery on the opposite side was considerably larger than usual.

[2] That the brain for the proper performance of its functions requires a certain amount of pressure, was, I believe, first pointed out by Dr. Hall, in his observations on the causes of syncope. Reference is elsewhere made to this subject in a note respecting the condition of the head after separation from the trunk. We find, in narrations of these cases, it is uni-

ENUMERATION OF THE CEREBRAL NERVES.

Nerves, as seen on the brain.

The *first pair*, or olfactory nerves, are seen passing forwards from nearly the inner border of the fissure of Sylvius; lying beneath the anterior cerebral lobes, and converging in their passage.

Second pair. The flat bands of the tractus optici are seen winding round the crura cerebri, assuming a cylindrical form as they approach each other; they unite to form the optic commissure, and then diverge as they pass to their relative destination.

The *third pair*, or motores oculorum, pass from the inner side of the crus cerebri near the pons, directing themselves forwards and outwards.

The *fourth pair*, or pathetic, are observed emerging from between the cerebrum and cerebellum, and taking a winding course downwards and forwards round the crura cerebri.

The *fifth pair*, or trigeminal, consisting of a small anterior portion, and a large posterior di-

formly stated that the head *does not bleed* for the space of some minutes. Surely this observation cannot extend to the first gush from the gorged internal jugular vein. Indeed, were it even true that this vein retained its blood, which is more than questionable, the position that syncope is the result of lost pressure, and that this is the condition of the severed head, would not be less tenable. It is not improbable that the increased activity of the brain which results from the excitement of intoxicating liquors, opium, &c., in moderation, is in great measure dependent on a certain increase of pressure, which, if augmented, induces stupor and drunkenness.

vision, pass outwards from their attachment to the angular junction between the pons and fore and under part of the crus cerebelli.

The *sixth pair*, or abducentes, take a diverging direction forwards from the grooved junction of the pons and medulla oblongata.

The *seventh pair*, consisting of portio dura or facial, and portio mollis or auditory, are connected to the posterior and lateral part where it is united to the crura cerebelli: they lie side by side, and direct themselves outwards.

The *eighth pair* consist of three divisions, glosso-pharyngeal, pneumogastric, and spinal accessory; they are found attached in the order above mentioned to the medulla oblongata and spinalis between the olivary and restiform bodies, the direction of their fibres being forwards and outwards.

The *ninth pair*, or lingual nerves, have their fibres attached anterior to the last-mentioned, viz. between the pyramidal and olivary bodies, where each is covered by the corresponding vertebral artery.

The student may now proceed with the dissection of the brain from above downwards.

DISSECTION OF THE CEREBRUM.

The brain being placed with its base downwards, the dissection of the cerebrum is commenced by slicing with a long narrow knife the surface of one hemisphere: a superficial layer being thus removed, the nature of the convolutions will be seen, each consisting of a medullary interior, projecting, as it were, into its cineritious capsule. From this disposition of parts there results the appearance which has been named *centrum ovale minus,* or a medullary nucleus surrounded by an extended layer of cortical substance. A second section, made nearly on a level with the corpus callosum, and through both hemispheres, will exhibit the relative extent and position of the two component substances of the brain, where this great medullary commissure is spreading into the interior of the cineritious structure of either side; this appearance is called *centrum ovale magnum.* The mode in which the convolutions are formed will now be understood, and it will no longer be matter of difficulty to comprehend how a quantity of fluid deposited in the interior of the brain, as in hydrocephalus, may, by its pressure, obliterate the sulci by unfolding the convolutions.

Relation of substances.

The arachnoid membrane and pia mater being now dissected off from between the hemispheres, together with the arteries, the *corpus callosum* will be exposed: this is named the great commissure of the brain, from its connecting the two hemispheres of the cerebrum: it is a broad medullary band, extended horizontally from before back-

Great commissure.

wards, and somewhat nearer to the anterior than the posterior border of the brain; curved upon itself longitudinally, but flat transversely; its anterior or narrower extremity is curved downwards and backwards, and forms the anterior division of the floor of the lateral ventricles: its posterior or broader extremity is reflected forwards, and assists the posterior pillars of the fornix in forming the medullary investment of the hippocampus major: its superior surface presents the *raphe*, an elevated ridge extending longitudinally along the median line; on each side of this is a slight groove lodging the arteries of the corpus callosum; and still further out, another line, converging as it passes forwards, may be seen: transverse lines extend outwards from the raphe throughout its whole extent: lastly, its inferior surface covers the lateral ventricles and their septum, and the fornix. The principal part of the substance of the corpus callosum consists of transverse fibres, which are continued into the medullary interior of the cerebral hemispheres.

The next stage of the dissection is to expose the ventricles and their septum; and for this purpose the corpus callosum should be carefully divided longitudinally on either side, at a little distance from the raphe: the handle of a scalpel being then introduced into the ventricle, and the central portion gently pressed to one side, the *septum lucidum* will be seen. This septum is lamellar and thin, broad from above to below anteriorly, narrow posteriorly; its form is therefore triangular: it is composed of two layers of medullary matter, connected superiorly and anteriorly to the corpus callosum, inferiorly and posteriorly to the fornix; these layers are more or less separated from each other, and thus is formed a small isolated cavity, called the *fifth ventricle.*

The corpus callosum being now divided in a transverse direction about its centre, each portion may be reflected: in doing this, the connexions of the septum should be again observed. The dissector must now proceed to lay open the lateral ventricles, for which purpose the handle of a scalpel, frequently cleansed in water, is the best instrument.

The *Lateral Ventricles* are cavities situated in the middle of the brain, diverging anteriorly, converging posteriorly, and dipping down into the central lobe. To facilitate description, each lateral ventricle has been divided into a body or central portion; an anterior or diverging cornu: a posterior or converging cornu; and an inferior or descending cornu[1].

Boundaries of lateral ventricles.

The *body* is horizontal and bounded above by the corpus callosum, externally by the medullary matter of the cerebrum, internally by the septum lucidum, inferiorly by its contents: the anterior

[1] Hence the appellation of '*tricorne*' applied to this cavity.

cornu is inclosed, as it were, by the anterior reflection of the corpus callosum; and the posterior cornu projects into the medullary substance of the posterior cerebral lobe: the inferior cornu, which must not yet be laid open, takes a winding course, first obliquely backwards and outwards; and then descending, is curved upon itself, and passes forwards with an inclination inwards, terminating in a cul-de-sac beneath the point at which it commenced, and behind the fissure of Sylvius: thence, this cornu forms a curve, the concavity of which faces forwards and inwards.

Before proceeding to the description of those bodies which are seen when the lateral ventricles are laid open, and therefore called their contents, we shall speak of the fornix.

The *Fornix* is a lamina of medullary matter, soft and fibrous; in position horizontal, and in form triangular; it bifurcates before and behind, to form anterior and posterior crura or pillars: the *body* or central portion lies between the corpus callosum and septum lucidum above, and velum interpositum, choroid plexus, and optic thalami below: anteriorly it is narrow, dividing into two short pillars, which are medullary and form the investment of the corpora mammillaria; these anterior pillars are not well seen till the fornix is reflected: the body spreads posteriorly, terminating in two broad flat bands, which invest the hippocampus of either side, and form their tæniæ.

Pillars of fornix.

Before dividing the fornix, the *foramen commune anterius* should be remarked; it is the opening by which the two lateral ventricles communicate together and with the third; the choroid plexus are thus connected. A probe may be passed through this aperture and left for a while. Now divide the posterior part of the body of the fornix carefully with a knife; reflect it backwards and forwards, and its anterior pillars will be seen descending between the probe, which marks the position of the foramen commune anterius, and a round cord (the anterior commissure), to be presently noticed: the inferior surface of the fornix, which rests upon the velum interpositum, is slightly grooved by its vessels; this appearance is called *lyra*[1]: its posterior crura may now also be traced.

The last piece of dissection has partly exposed the third ventricle; the description of this, however, must be deferred till the contents of the lateral ventricles have been considered.

Contents of lateral ventricle.

The parts seen in each lateral ventricle are, corpus striatum; thalamus opticus; tænia thalami optici or semicircularis; plexus choroides; hippocampus major; tænia hippocampi or corpus fimbriatum; corpus denticulatum; hippocampus minor.

[1] One of the many absurd anatomical similes. It is of course intended that the fornix should be preserved; or indeed, after this view it may be replaced.

Corpus striatum, grey and pyriform, presents a large bulbous extremity directed forwards and inwards, and a tapering extremity pointing backwards and outwards; its position is therefore oblique and along the floor of the body of the ventricle: above, it is covered in by the roof of the ventricle, and externally and inferiorly, continuous with the substance of the hemisphere; whilst the internal surface of each is separated from the opposite body of the same name by the optic thalami, which are, as it were, wedged in between them; anteriorly, the anterior commissure connects them. Their *structure* consists of alternate laminæ of grey and white matter[2], disposed vertically and seen on section; the medullary bands are derived from the olivary bodies. A number of small veins pass from their surface to the venæ Galeni.

The *Thalamus opticus*[3] is not thoroughly seen till the third ventricle is opened; it may, however, be now described. It is like the striated body a pyriform eminence, with its anterior extremity, however, smaller than the posterior. *Connexions*: superiorly, it forms part of the floor of the body of the lateral ventricle, supporting the choroid plexus, and covered by the velum interpositum and corpus callosum; the inferior surface

[2] Whence the name 'corpus *striatum*.'

[3] These bodies are named by Gall, the *inferior great ganglia* of the brain.

is in the descending cornu of the ventricle, and presents externally two tubercles, the *corpora geniculata*; the external surface is continuous with the corpus striatum; and the internal surface is connected to the opposite thalamus anteriorly by the *commissura mollis,* a soft cineritious band, which is not preserved unless considerable care be taken to support the hemispheres; and posteriorly by the posterior commissure, to be presently noticed; this surface will be found to form the lateral boundary of the third ventricle; its anterior extremity is opposite the foramen commune anterius, before noticed; whilst its posterior is in contact with tænia hippocampi. In *structure* these bodies are medullary externally, and internally cineritious; the blending of the white investment with the grey interior produces striæ. Fibres, derived originally from the olivary body, after passing through the crus cerebri, take their course through this structure.

Tænia thalami optici, or tænia semicircularis: this is a narrow band of pale grey substance about a line and a half in breadth, semitransparent and fibrous, and occupying the groove between the corpus striatum and optic thalamus; its course is therefore semicircular; commencing near the corpus geniculatum externum, it passes forwards and inwards, and is lost in or near the anterior pillars of the fornix. The extent of this body may be best distinguished by the small veins which may be seen crossing beneath it from the corpus striatum to join the venæ Galeni. At its anterior part, a thin horn-coloured lamina has received the name of *lamina cornea.*

The *Choroid plexus* consists of folds of the pia mater, in which ramify small arteries and numerous small veins; it is attached by one margin to the choroid web or velum interpositum, (to be presently described,) whilst the other is loose and floating: it is thus found first in the inferior cornu of the lateral ventricle, between the optic thalamus and tænia hippocampi, thence ascending in an oblique direction, and extended along the margin of the fornix; at the foramen commune anterius, it is continuous with that of the opposite side. The choroid plexus is enveloped by arachnoid membrane, which is continued around it from the inferior surface of the velum. In its Veins. course it receives veins from the corpus striatum and other parts of the ventricle; these terminate in the venæ Galeni. These membranes not infrequently contain small serous cysts, or hydatids.

Hippocampus major[1]: this considerable convolution, for it appears little else, occupies the floor of the inferior cornu of the ventricle; and curved upon itself, it presents its concavity forwards and inwards: it is terminated by an expanded bulbous extremity, which, from its tuberculated appearance, receives the name of *pes*

[1] Or cornu Ammonis.

hippocampi. With respect to its connexions, its superior surface has resting on it the choroid plexus; its inferior surface is continuous with the substance of the brain; external to the groove which bounds its convex margin is a second elevation or convolution, more or less distinct, which is named the *pes accessorius*[1]; whilst its concave margin is in contact with its tænia. The interior of this body *consists* of cineritious matter, which is continuous with the same substance in the posterior and middle lobes of the cerebrum[2]: its investment of medullary matter is directly derived from the posterior pillars of the fornix.

Tænia hippocampi, or corpus fimbriatum.—This is a narrow medullary band, also derived from the posterior pillar of the fornix, which passes along the concave margin of the great hippocampus, having its own internal edge free: on raising this free edge, a cineritious denticulated line is brought into view, which has received the name of *corpus denticulatum.*

Hippocampus minor.—This, which is the last body we have to notice in the lateral ventricle, is an elevation or convolution in the floor of the posterior cornu; *consisting*, like the *great* body of that name, of a cineritious interior derived from the posterior cerebral lobe, and receiving

[1] Additamentum pedis hippocampi.

[2] A section may be made to show this, without interfering with the future dissection.

its medullary investment from the posterior pillar of the fornix.

Let the replaced fornix be again turned back, and a broad expanded membrane on which it rested will be exposed: this is the *choroid membrane*, or *velum interpositum*. In tracing the pia mater on the surface of the brain, the layer that envelopes the posterior margin of the corpus callosum will be found approximating to that portion which covers the superior surface of the cerebellum, and the conjoined layers will then be found entering the transverse fissure, inclosing between them the venæ Galeni. The membrane is here broad and extended; but narrowing as it passes forwards, it assumes a triangular form, covering the arachnoid canal, the tubercula quadrigemina, the pineal body[3], the optic thalami, and third ventricle: the fornix rests on it anteriorly, and the corpus callosum posteriorly: its edges are connected anteriorly to the choroid plexus, but posteriorly are free; and its anterior margin is continuous with the junction of the same plexus at the foramen commune anterius. The velum receives a delicate investment of arachnoid membrane, which is continued along its inferior aspect from the surface of the brain, by the foramen Velum.

[3] Except where its pedicles go out: "therefore," as Mr. Flood observes, "this gland is related to the pia mater precisely as the pituitary gland is to the dura mater."—*Flood's Nervous System*, p. 32.

of Bichat[1]. The *venæ Galeni*, having received the blood from the plexus, pass back between the layers of this membrane, in the median line, and terminate either separately or together in the straight sinus[2].

The velum interpositum must now be carefully raised and turned back, and we get a better view of some objects which have already been described, viz. the arachnoid canal of Bichat, and the optic thalami with their corpora geniculata and connexion with the tubercula quadrigemina, forming the origin of the optic nerves. The description of the pineal body and tubercula quadrigemina will be deferred till after the third ventricle and commissures have been examined.

The commissures.

If the thalami be gently separated, a soft cineritious band will be observed passing between these bodies and connecting their opposed surfaces; this is the *commissura mollis*: it is continuous with the cineritious portion of the thalami, and of so tender a structure, that the slightest force causes it to yield, and leaves no trace behind[3]. Crossing transversely, immediately in front of the anterior pillars of the fornix, is seen a round white cord, in size equalling the optic

[1] See *Arachnoid Membrane—internal division.*

[2] See the description of the sinuses.

[3] A fresh brain is necessary, and then care should be taken to support the hemispheres during the dissection. I have seen this commissure very firm and distinct in cases where there has been effusion into the ventricles.

nerve; this is the *anterior commissure*: it is curved with its convexity forwards, and flattened laterally, as it passes to be imbedded in either hemisphere: its fibres may be *traced* to the corpus callosum and crura cerebri[4]. Thirdly, the *posterior* commissure is situated immediately in front of the tubercula quadrigemina and pineal body; also transverse in direction and cylindrical in form, but shorter, thicker, and more distinctly fibrous than the anterior commissure: the former further differs from the latter in not being free in its centre, but it is connected inferiorly to the peduncles of the pineal body, and posteriorly to the tubercula quadrigemina; either extremity is attached to the optic thalamus, but its fibres cease abruptly and cannot be traced into the hemispheres[5].

We are now prepared to examine the third ventricle, of which these commissures partly form the boundaries. The optic thalami must be gently drawn asunder, and then the extent and parietes of this cavity[6] are seen.

[4] Tiedemann, Cloquet, Chaussier.

[5] Therefore, as Sir Charles Bell observes, "this cord does not deserve the name of commissure: for it is lost in the neighbouring border of medullary matter, and is merely this matter reflected, so as to present a rounded edge."—*Bell's Anatomy*, vol. ii. p. 456.

[6] Or rather longitudinal sulcus; for when the parts are in their natural position and condition, nothing more than a superficial fissure exists between the contiguous thalami: this should be remarked before destroying the connecting soft commissure.

Boundaries of third ventricle.

The *Third* or *middle ventricle* is situated between the thalami optici, which therefore form its lateral boundaries; anteriorly it is bounded by the anterior commissure and descending pillars of the fornix, and in like manner posteriorly by the posterior commissure, pineal body, and tubercula quadrigemina; above, it is covered by a roof of those parts already removed, viz. the fornix and velum interpositum; whilst its floor, whose longitudinal extent is greater, consists of the tuber cinereum, corpora mammillaria, and locus perforatus[1].

Outlets.

There are three outlets from this ventricle, named according to their relative position; superiorly and anteriorly, the *foramen commune anterius,* which is the opening common to this and the lateral ventricles, by which the choroid plexus unite; posteriorly, the *foramen commune posterius,* commencing a canal which leads backwards and downwards between the pons Varolii and tubercula quadrigemina to the fourth ventricle, and thence named *iter a tertio ad quartum ventriculum,* or aqueductus Sylvii: inferiorly and anteriorly the floor of the ventricle is contracted into a sort of funnel at that part corresponding to the position of the pituitary body; this is the *infundibulum,* which, however, can scarcely be called an outlet from the ventricle, as it is impervious, and, as Cloquet remarks, is never

[1] Parts already examined in the base of the brain.

prolonged into the pituitary shaft[2]. The pineal body and tubercles are the next parts to be noticed.

The *pineal body* is placed upon the tubercula quadrigemina, but unattached to them: it is grey and about the size of a large pea, being, however, not round, but broader at its anterior part, whence two little medullary bands pass off in a diverging direction, to terminate in the upper and inner part of the optic thalami; these small cords are the *peduncles* of this body, and the only medium by which it is connected to the brain[3]. In the interior of this body, and sometimes externally, are found yellowish gritty particles of a siliceous appearance[4]; otherwise this little body is pulpy and yields readily under the pressure of the finger. No use has been assigned to this so-called gland[5]. Structure.

[2] Knox's Cloquet, p. 425.

[3] Gall describes peduncles connecting it to the tubercula quadrigemina: I have never seen them.

[4] Composed of the same earthy constituents as bone, viz. principally phosphate and carbonate of lime. This substance is not usually met with till about the fourteenth year. The Wenzels mention having met with it from the age of seven; and also mention that it is occasionally wanting; this I noticed in an adult brain I was lately dissecting. At any rate it appears to be admitted that this structure belongs to the healthy normal state of the brain at puberty. Soemmerring says it is found but in few animals.

[5] Sir Charles Bell says that he found this body surrounded by pus in an idiot boy who died of hydrocephalus; that he has seen it degenerated into hydatids; and that it is sometimes

On removing the pineal body, the *tubercula quadrigemina*[1] are completely exposed. These bodies are placed behind the third ventricle, and above and before the fourth; the two superior are named *nates*, the two inferior *testes*: they are all united at their bases, forming a sort of central commissure, and separated only on their surface by two grooves intersecting each other at right angles. A section shows them to consist of cineritious matter with a medullary investment, and proves an interchange of fibres between either side. Both nates and testes are connected laterally by medullary bands to the thalami; and the latter posteriorly to the valve of Vieussens and two medullary processes, which we now proceed to notice under the title of *processus e cerebello ad testes*. Nearly cylindrical in form, and diverging slightly as they descend backward from their connexion to the testes, these bodies pass to terminate posteriorly in the interior of the cerebellum[2]. The *valve of Vieussens* is a triangular lamina of cineritious matter stretched between and attached to the inner borders of the last-described processes; posteriorly, connected to the

Structure of tubercles.

wanting. (*Bell's Anatomy*, vol. ii. p. 455.) It was supposed by Galen and Descartes that the pineal body was the seat of the soul.

[1] These bodies, it may be noticed, though described here for the sake of convenience, belong to the pons Varolii.

[2] These fibres will be traced when the cerebellum is dissected.

cerebellum, and anteriorly, as before noticed, to the testes: this valve covers in the fourth ventricle[3], and presents its broader margin or base towards the cerebellum. The student may, at this stage of the dissection, examine the origin of the fourth or pathetic nerve; it usually arises from the side of the valve of Vieussens near its junction with the testes. A director or probe should now be passed backwards from the third ventricle along the aqueduct of Sylvius, and the tubercula quadrigemina and valve of Vieussens carefully divided[4].

The *Fourth ventricle*, or ventricle of the cerebellum, is bounded in the following manner: above, by the valve of Vieussens; below, by pia mater and arachnoid membrane at their reflexion from the cerebellum on to the cord; before, by the medulla oblongata; behind, by the anterior notch of the cerebellum; on either side, by the processus à cerebello ad testes. In this ventricle we remark in its floor a fold of pia mater, vascular and sometimes granular, named the *choroid plexus* of the fourth ventricle: on its anterior wall a longitudinal groove in the medulla oblongata, named *calamus scriptorius*, and white trans- Boundaries.

[3] Therefore, also called the valve of the fourth ventricle.

[4] It will be remarked that the description has followed the course of dissection; it being deemed better not to interfere with this object by commencing yet the description of the cerebellum, to which part of the brain the fourth ventricle and its boundaries belong rather than to the cerebrum.

verse lines passing to the auditory division of the seventh pair of nerves.

Before passing to the next division of the subject, we have in concluding the description of the cerebrum to notice its crura[1]. The *crura cerebri* are seen emerging from the lateral and anterior part of the pons Varolii; and thence ascending forwards and outwards, each terminates by passing into the corresponding hemisphere. The *fibres* of the crura cerebri are found on dissection to be longitudinal and in bundles: these fasciculi, which are medullary, are intermingled inferiorly with cineritious fibres; but a transverse section presents a semilunar spot of deep grey matter, which is darker and firmer than the rest of the brain; this, from its appearance, which is often of a blackish hue, has received the name of *locus niger*. The medullary fibres of these crura are derived principally from the corpora pyramidalia, whence they may be traced through the pons Varolii to their destination.

Structure of crura.

CEREBELLUM[2].

Having already disposed of the fourth ventricle

[1] These may be examined now, or their dissection deferred till the pons Varolii comes under notice. For their relative connexions the reader is referred to the description of the base of the brain.

[2] "The cerebellum is less than a third of the size of the brain. Its weight, which varies much according to the different ages, is commonly in the adult man the eighth or ninth

and its boundaries, this division will detain us for a comparatively short space of time.

The *Cerebellum* is lodged in the posterior and deepest part of the skull, the occipital fossæ, behind the petrous portions of the temporal bones. Lying beneath the posterior lobes of the cerebrum, it is separated from them by the interposition of the tentorium[3]. We shall first describe the exterior, and subsequently proceed to examine the interior of this division of the brain.

The cerebellum is greatest in extent from side to side; convex below, where it corresponds to the occipital fossæ, and nearly flat above, where it is adapted to the tentorium. Like the cerebrum, it is divided into two symmetrical portions by a deep median longitudinal fissure, which cuts it inferiorly and posteriorly, and receives the falx cerebelli. The surface presents a series of concentric lamellæ, convex backwards and separated by grooves; these are analogous to the convolutions of the cerebrum, and are, like them, covered by a closely investing portion of the pia mater which dips down between these interstices, whilst the arachnoid merely passes over them. On the Form. Coverings.

part of that of the brain, and the sixteenth or eighteenth in the new-born infant."—*Knox's Cloquet*, p. 407.

[3] Which, it will be remembered, is that portion of the dura mater that extends along the broad groove marking the course of the lateral sinus, thence to be attached to the superior angles of the petrous bones as far forward as the side of the sella turcica. See *Dura mater*.

Processes. superior surface, in the median line and anteriorly, is a ridge or prominence named the *superior vermiform process.* Inferiorly and posteriorly is a similar eminence which is fissured transversely; this is the *inferior vermiform process*; the rounded anterior extremity of this process is called its *mammillary eminence.* Emerging from either hemisphere anteriorly, a rounded cord is remarked, which converges rapidly towards the median line, passing at the same time upwards and forwards to terminate in the pons Varolii; these are the *crura cerebelli.*

Structure. The cerebellum, like the cerebrum, consists of cineritious and medullary matter. To obtain a view of the relative disposition of these substances, a vertical section should be made longitudinally through the centre of either lobe, and the following appearance will present itself: the dark cineritious substance occupying, as in the cerebrum, the exterior; and extending backwards into the lobe, a trunk of medullary matter, which branches off and forms ramuscules that spread out in every direction, approaching the surface but still enveloped by the cortical matter, which latter *appears* to predominate in quantity. The appearance thus produced by this section is named *arbor vitæ.* The vermiform processes, when cut into, will be found likewise to consist of a cineritious exterior, inclosing medullary matter continuous with that above described.

If we now proceed to trace the medullary fibres of the cerebellum backwards, we shall find them derived from the following three sources: 1. the crura cerebelli; 2. a prolongation from the corpora restiformia, which attaches itself to the inner side of the corresponding crus; 3. the processus à testibus ad cerebellum[1], which is found above and to the inner side of the crus: these bodies pass back together, penetrating the hemisphere of the same side to which they belong, and terminate in ramifications as already described. It remains for us to notice, in the centre of this medullary portion, a small oval mass of cineritious substance, with irregular serrated margin, of firm consistence, and darker than the other cortical substance of this part of the brain; this is the *corpus dentatum*[2]. A transverse section is the best to show the relative proportions of the white and grey matters. Corpus dentatum.

PONS VAROLII[3].

This, which is by far the smallest of the three divisions of the brain[4], has a central situation in

[1] Or *processus à cerebello ad testes*; for, as Sir Charles Bell observes, "these are only modes of speaking; we have no authority in nature for following the nerves or processes of nervous matter, in one direction, more than another." (Anatomy, ii. 459.)

[2] This body is also named *rhomboideum* and *serratum*; Cloquet says it is only seen with great difficulty in children.

[3] Also named *cerebral* or *annular protuberance*.

[4] Weighing, according to Cloquet, about the sixtieth or sixty-fifth part of the whole brain. (Anatomy, p. 410.)

relation to the cerebrum and cerebellum, to which bodies it is united through the medium of their crura. Form. Its *form* is square, and its transverse rather less than its vertical diameter. Of its surfaces, the anterior is convex and rests on the Surfaces. smooth hollow of the basilar process; its facing is therefore forwards and downwards: we remark here a longitudinal depression or *raphe*, which lodges the basilar artery, and small transverse grooves which mark the course of its branches. Its posterior surface faces backwards and upwards, and presents the tubercular quadrigemina, &c., which have already been described with the fourth ventricle. Superiorly and ante- Connexions. riorly is its connexion with the crura cerebri; inferiorly and laterally the crura cerebelli pass off, and between them is seen the attached extremity of the medulla oblongata. The *structure* of the pons is very firm and fibrous: dissection exhibits the course of the medullary tract of the corpora pyramidalia passing up through the pons to the crura cerebri: it shows the union of the crura and pons, and the transverse medullary fibres passing from one crus cerebelli to the other. Thus, the pons seems to stand in the same relation to the lateral portions of the cerebellum, that the corpus callosum does to the cerebrum[1].

[1] Or, to use Sir Charles Bell's words, "that it is the great commissure of the cerebellum, uniting its lateral parts and asso-

ciating the two organs." This author adds, "No decussation can be observed; fibres run transversely across like a commissure, but the tract of matter is direct and parallel, not oblique; therefore, we must seek for some other cause than such supposed decussation to account for the fact that an injury to one side of the brain produces a loss of power on the opposite side of the body." This, however, is not constant, as proved by cases related by Bell and others. For interesting and accurate information on these pathological points, the reader is referred to Abercrombie's *Diseases of the Brain*, and Andral's *Clinique Médicale*, in which, together with Dr. Bright's *Medical Reports*, will be found probably the most recent collection of facts.

SECTION II.

MEDULLA SPINALIS.

Directions for opening spinal canal.

For the purpose of dissecting the spinal cord throughout its whole extent, it is necessary to remove it from the subject without destroying its connexion to the brain; this must be effected in the following way: place the body with the face downwards, and having divided the integuments along the spinous ridge from the occiput to the coccyx, reflect them on either side, and then saw vertically through the posterior parts of the arches of the vertebræ between the transverse and spinous processes: the section may be completed by the aid of the mallet and chisel: the connexions of the dura mater being then liberated, particularly around the foramen magnum, the cord and its membranes may be drawn up through the occipital hole, at the same time that the brain is removed in the usual manner. To preserve and show the different component parts and form of the spinal marrow, Bellingeri recommends that it should be placed for a time in nitric acid diluted with water; the strength is sufficient if the acid taste be perceptible. This remark is equally applicable to the brain.

The *Spinal marrow* is surrounded by three membranes, which are analogous to and continuous with the membranes of the brain: we will describe these, before we proceed to examine the structure of this division of the nervous centre. Membranes.

The *Dura mater* of this region, or, as it is commonly called, *Theca vertebralis*, descends from the occipital foramen around the spinal cord, not ceasing till it reaches the termination of the sacral canal, into which it becomes attached or inserted. Cellular tissue will be found to separate it from the vertebral canal, except where it is adherent to the common posterior ligament of the spine; and moreover it will be remarked that it does not form a close investment to the cord, but only loosely envelopes it: in both these particulars it differs from the cerebral dura mater; alterations which are no doubt adaptations to the peculiar relation this tender viscus holds to the flexible bony canal that contains it. Each nerve, at its exit from the vertebral canal, receives a sheath of this membrane, which accompanies it out of the foramen and is then continuous with the neighbouring cellular tissue[1]. The internal surface of the theca is lined by arachnoid membrane, which we now proceed to trace[2].

[1] Not continued into the periosteum, as is the case around the skull. (Knox's Cloquet, p. 431.)

[2] The theca is very tough, and capable of resisting consider-

Serous membrane.

Having laid open the dura mater of the cord, its smooth and shining interior is exposed; for by such division of the theca, we also lay open the *arachnoid* or *serous sac.* This membrane consists, as in the brain, of an investing and a reflected layer: we will commence tracing it from the occipital foramen, where it is continuous with the cranial arachnoid. The *investing* or visceral layer is prolonged downwards around the cord, to which it is but loosely connected; and in its descent sends off upon each nerve a tubular envelope, which is reflected upon the dura mater just as the nerve perforates the latter; moreover it is reflected around each vessel that pierces the theca: this disposition of the arachnoid gives a serrated appearance to the sides of the cord, which, however, is not the ligamentum dentatum; this will be presently described. We find it then continued downwards beyond the termination of the spinal marrow, forming a tubular prolongation which is reflected on the dura mater at the lower part of the sacral canal[1]; thence it may be traced upwards and found continuous with those portions which are reflected from the nerves and vessels, thus lining the whole theca and arriving

able force. In a case of fractured vertebra with displacement which I examined, the cord was completely divided, but the theca scarcely injured.

[1] This membrane, and particularly the portion last alluded to, is best exhibited by insufflation: its loose connexions to the spinal cord are then also demonstrated.

at the occipital foramen. The *office* of this membrane to the spinal cord is similar to that of the analogous membrane to the brain; presenting a highly lubricated surface, which allows of the free and extensive motions of the spine without interfering with or injuring the tender organ contained. Use.

The proper *investing tunic* of the spinal cord has been described by some anatomists as a continuation of the pia mater, and by others as a distinct tissue. If not actually a continuation of the investing membrane of the brain, it commences where the latter ceases, and holds an analogous relation to the cord. It is vascular, though sparingly and not uniformly; dense[2] and almost inseparably connected to the cord, though not adherent to the investing arachnoid, and decreasing in density as it approaches the occipital foramen. Its toughness will allow of the marrow being pressed out from it, between the finger and thumb. Supporting membrane.

The *Ligamentum dentatum* may be distinguished from the serrated edge of the arachnoid: it forms a narrow supporting band which descends through the vertebral canal, attached to either side of the cord between the anterior and posterior roots of the nerves. The apices of its denticulations are adherent to the dura mater at

[2] Cloquet calls it fibrous, and says it is continuous with the neurilema of the vertebral nerves. (Anatomy, p. 441.)

the interval between each pair of nerves, as low as the lumbar region[1]; whilst internally it seems continuous with the investing membrane of the cord. Delicate glistening bands which connect the denticulations are not unlike, in appearance and structure, to the finer tendinous cords of the heart. Having disposed of its membranes, we now proceed to describe the spinal cord itself.

Divisions of spinal marrow.

The *Medulla spinalis* commences at the inferior extremity of the pons Varolii, under the title of *Medulla oblongata*; this, diminishing in diameter as it leaves the skull, descends through the spinal canal to the first or second lumbar vertebra, where its cord-like form is lost, and it terminates in the *Cauda equina*. These three divisions, then, may be severally named the head, body, and tail of the spinal marrow[2]. In *form*, the cord is cylindrical, but not uniform in volume. As previously noticed, it is not closely invested by its theca, but is, nevertheless, immovably fixed in its place by the thecal processes around the nerves and the ligamentum dentatum. Its situation is somewhat nearer the anterior than the posterior wall of the spinal canal, to which alone, it will be remembered, the dura mater is adhe-

[1] There are therefore about twenty pairs of denticulations.

[2] The weight of the spinal marrow varies from the nineteenth to the twenty-fifth part of the whole brain, in the adult man. It is lighter and does not descend so low in the child. (Cloquet, p. 411.)

rent. It may be added, that the cord admits of some degree of extension and contraction of its length, by which it accommodates itself to the motions of the spinal column. We will examine each of the above-mentioned divisions in turn.

The *Medulla oblongata* is that portion of the spinal marrow which is contained within the skull. Its connexion above to the pons is marked by a deep circular groove or sulcus, immediately below which it forms a bulbous expansion; this contracts as it descends to the occipital foramen, through a space of rather more than an inch in extent. The adherent membrane should be removed from this division, and the following objects may then be examined. Head of spinal cord.

Anteriorly, the *Corpora pyramidalia,* two eminences which extend from the inferior margin of the pons, where they are prominent, for a space of rather less than an inch downwards, when they are lost: a deep longitudinal fissure separates them in the median line; this terminates above in the foramen cæcum. *Corpora olivaria*: these are oval bodies connected to the lateral part of the pons, and separated by a shallow groove from the last described, than which they are more prominent. The *Corpora restiformia* are the eminences on the posterior surface of the medulla oblongata: they also are oblong and separated from each other by the lower part of the calamus scriptorius. Between these two last bodies is the track or column described by Sir Charles Bell as giving rise to the nerves of respiration.

Dissection of medulla oblongata. A dissection of the above bodies presents us with the following appearances. The *corpora pyramidalia* are found to decussate near the pons[1], and thence proceeding upwards, their medullary fibres may be traced through the cineritious substance of the pons, into the crura cerebri. The *corpora olivaria* contain grey matter; they take their course, like the preceding, through the pons, and may be traced to the inner part of the cerebral crura, and thence to the thalami nervorum opticorum. The *corpora restiformia*[2] may be traced up to the inner side of the crura cerebelli, and thence, with other bundles of white matter, into the cerebellum, of which it assists in forming the medullary interior[3].

[1] Giving rise to the remarkable peculiarity with regard to these bodies, that they do not contribute to form the brain on the same side as that on which they originate. (Cloquet, p. 417.) "It has been fully ascertained that disease confined to one hemisphere of the cerebrum, or of the cerebellum, and to one side of the mesial plane in the tuber annulare, constantly affects the *opposite* side,—whilst disease, confined to one of the lateral columns of the medulla oblongata and medulla spinalis, affects the *corresponding* side of the muscular system. The encephalon has a *crossed* effect; the medulla a direct effect."—*Hall's Lectures on the Nervous System*, p. 34.

[2] Also called *processus à medullâ spinali ad cerebellum.*

[3] See the dissection of the cerebellum.

The *body* of the medulla spinalis extends as low as the first or second lumbar vertebra, before it terminates in the cauda equina. Its *curvatures* of course correspond to the curvatures of the spinal column. We have to remark its relative volume at different parts; its transverse and longitudinal sulci; and its internal structure.

Proportions of spinal cord.

As the cord enters the spinal canal, immediately below the medulla oblongata it becomes much contracted, but again swells between the third and seventh cervical vertebræ. At the termination of the cervical and upper part of the dorsal regions its circumference is again diminished, to be once more increased from the middle to the lower part of the dorsal division: lastly, from the last-mentioned point it decreases to its extremity; not being, however, directly fusiform, but forming first an oval tubercular expansion, and then terminating by one of a more conical form. The two *bulgings* of the cord correspond to the origin of the brachial and lumbar plexus of nerves[4].

Grooves.

Along the spinal cord may be seen, at short intervals, small *transverse grooves*: these are

[4] For, it must be remembered, these plexus do not arise immediately opposite their points of exit by the spinal foramina; but, the lower down, the more oblique the course they take previous to their emergence from the canal. See *Spinal nerves*.

most distinct on its anterior face and in the upper two thirds of the dorsal region[1].

The *longitudinal grooves or fissures* are six in number; two median, and four collateral. The *median* fissures extend through the whole course of the body of the cord; the anterior the deeper, commencing between the corpora pyramidalia, the posterior descending from between the corpora restiformia: they cut the cord so deeply as to give it the appearance of two rounded columns, somewhat flattened internally and adapted to one another. A careful examination of the bottom of these sulci will show that they are each lined by a layer of medullary matter, of which the fibres are transverse in the anterior, and longitudinal in the posterior groove. On either side of the median sulci, anteriorly and posteriorly, are the *collateral grooves*: a considerable space intervenes between these and the former: they are comparatively shallow[2], and mark the lines of origin of the double roots of the spinal nerves. The two *anterior* collateral grooves commence between the corpora pyramidalia and olivaria, and the two *posterior*, which are more distinct, between the

[1] These are no doubt connected with a property of the cord already alluded to, viz. its capability of becoming contracted or extended longitudinally during the motions of the spine.

[2] These grooves are much more distinct in newly-born children than in adults. (Cloquet, p. 413.)

corpora olivaria and restiformia; both becoming more marked as they descend. When the nerves are removed, the orifices of their insertions may be seen, disposed in regular succession along these grooves.

The *respiratory column* cannot be traced below the medulla oblongata: on this subject Sir C. Bell remarks, "I imagine that the same column or track which gives origin to the fourth, seventh, glosso-pharyngeal, par vagum and spinal accessory nerves is continued downwards along the lateral part of the spinal marrow, and that it affords roots to the spinal nerves, constituting them respiratory nerves, as well as nerves of motion and sensation; and that it especially supplies the roots of the diaphragmatic nerve, and the external respiratory nerve[3]."

To exhibit the internal structure of the spinal marrow, transverse sections should be made at different parts. Throughout it will be remarked that the medullary exterior incloses a quantity of cineritious matter which is more abundant in the cervical and lumbar regions; though still exceeded, except perhaps at its lowest part, by the medullary matter. A figure will best describe its

[3] Bell's Anatomy, vol. ii. p. 399. For further remarks the student is referred to the physiological section. The column mentioned in the text is described on the authority of Sir Charles Bell: the student must not be disappointed if he do not always find the track mentioned.

shape: the form of the cineritious substance at the commencement of the medulla spinalis is thus,)(; in the rest of its course thus,)—(; except at its extremity, where it is nearly quadrilateral[1].

The *tail* of the spinal marrow, or, as it is commonly called, *cauda equina,* occupies the spinal and sacral canal below the second lumbar vertebra. As before stated, the lumbar and sacral nerves take a very oblique and consequently long course before they quit the spinal canal; the resulting appearance is the cauda equina[2].

[1] It may be remarked that the younger the subject, the more abundant the grey matter of the cord. For ample information on the structure of the spinal cord, see Bellingeri *De Medulla spinali Nervisque.*

[2] It will be remarked that all points not purely anatomical have been avoided in the preceding description. For the true physiological division of the spinal cord, the student is referred to the next section.

PART II.

PHYSIOLOGY OF THE NERVOUS SYSTEM.

PART II.

PHYSIOLOGY OF THE NERVOUS SYSTEM.

In the following observations it is not intended to give a history of the course and progress of our knowledge on the subject of the Nervous system; nor would it be less inappropriate to enter into a detail of the various opinions and speculations of physiologists in our own day: this mode of treating the subject would lead to extended digressions widely at variance with the objects of this work, and incompatible with desirable conciseness. It is proposed simply to lay before the reader an outline which shall comprehend such points as most satisfactorily account for the functions of the different parts of the nervous system, and by which pathological phenomena are most readily explained: thus embracing a view, in short, by which he may be best aided in his diagnosis and treatment of disease—for such should ever be the aim and object of physiological investigation—and which he may therefore turn to the most *practical* account[1].

[1] The objects here stated will, I trust, be sufficient excuse for my scrupulously avoiding, after this note, any allusion to the individual functions of the mind as connected with and

In casting a glance over the different aggregated portions or centres, if we may so term them, of the nervous system, we might be led to an inquiry respecting the relative value and independence of each in the animal economy; and in this inquiry we might justifiably hope for assistance by noting the phenomena accompanying anormal nervous development and its relative frequency, and also from comparative anatomy: nor are the results which we are able to gather from so ample a field for observation, without their utility. Instances of the birth of fœtuses without cerebrum or cerebellum, and their survival even for a period of many hours, during which various functions requiring nervous influence were performed, are replete with interest, as indicating how much organic life is independent of these organs: but we shall have occasion to recur to this point, in illustration of an important division of our subject.

influenced by the brain. That this is a subject of extreme interest, even in a practical point of view, as far as relates to insanity, there can be no doubt; but the many discrepancies and contradictions which exist in the complicated system of subdivision of this organ, for the purpose of assigning to each its proper function, serve to prove how little is really known about the matter. At best, how much of the brain is left unaccounted for: how unaccountable it is (without, however, discussing the merits of phrenology,) that extensive lesions, abscesses, nay, loss of structure, may take place with scarcely an attendant or consequent symptom! The more purely metaphysical inquiry concerning the actual relation and connexion of the material with the immaterial part of our nature is, of course, no business of the physiologist.

In the inferences which we draw from comparative anatomy we should be more cautious. It is true, indeed, that "as we descend in the scale of animal existence, we find the brain and cerebellum disappear before the spinal marrow;" and this would tend to a deduction of the same inference as that drawn from the previous argument: but it is a mistaken notion to suppose that the nervous system of animals of a still lower grade consists solely of a sympathetic system: the analogy can hold good, in appearance only, between the ganglionic chains of the lower articulated classes, and the sympathetic ganglia of vertebrated animals; for in function they are not identical, and this implies non-identity of structure[1].

But to proceed. The principal functions of the nervous system may be classed under three great heads,—sensation, muscular action, assimilation: the production of animal heat may be classed with the last. To unravel and classify the subdivisions of these heads, and to assign, as

[1] "The simple form of the nervous system presented by the lowest articulated class resembles the embryo form of this system in the higher classes of this division, and corresponds remarkably with the first perceptible form of the spino-cerebral axis in all the vertebrated animals, where it appears a double white streak on the outer layer of the germinal portion of the cicatricula. These simple worms, consisting solely of the trunk, present also the embryo form of the whole body of the highest articulated classes, &c."—*Outlines of Comparative Anatomy*, by Robert E. Grant, M.D., &c., p. 187.

far as may be, to each department of the nervous system the part it plays and the functions it controls, will be the object of the subsequent observations.

To Legallois and Sir Charles Bell is due the merit of having pointed out that the medulla oblongata is the source of the respiratory motions; a fact which the latter physiologist has since so fully developed as his respiratory system: whilst to Flourens we are indebted for having subsequently determined that the cerebrum was the source of sensation and volition. The sympathetic has long been considered to control the processes of assimilation. Without entering for the present into proofs[1], let us briefly consider the meaning and application of these terms.

First of *Volition.* By this term is meant the power of willing an action, and it is applied to the control exercised by the will over muscles which are capable of being so influenced. Such power ceases the moment that the cerebrum is destroyed.

Sensation, literally defined, means perception through the medium of the senses: our ideas of sensation must not, however, be confined to this definition in its common acceptation; for, though diffused in a more or less perfect degree over the

[1] As much as is thought necessary of these proofs will be found attached to the individual nerves, more particularly the sympathetic system and pneumogastric nerves.

surface of the body, the sense of touch—by which is meant the capability of distinguishing between hot, cold, rough, smooth, &c.—is but a modification of common sensation, depending, apparently, for its degree of perfection on the actual amount of nervous matter distributed to a given space, and in part the result of habit or experience: but we must include all impressions of which the *sensorium* is capable of being made cognizant; identifying with this definition sensations of a pleasurable or painful nature, and regarding them merely as deviations in excess. We shall have to return to this subject; and for the present will only warn the reader against classing with sensation a somewhat analogous property resident in the organs of contraction and assimilation, viz. the capability of being stimulated to the performance of a function by an appropriate stimulus: this also implies an impression; but, as will by and by be shown, of a character which may be totally independent of the sensorium, and to which the distinguishing title of "appropriate excitability" or (to use a more familiar one) "irritability" may be given.

Assimilation, or the results of vascular action, include deposition—absorption—secretion—exhalation. Individually the existence of these actions is more or less evidenced by all living organized matter; collectively, they form the functions of organic life in animal matter. The ganglionic or vegetative[1] system presides over these actions, and is consequently the ultimate directing and balancing agent in nutrition, growth, and decay[2].

With regard to the production of *animal heat*, there is every reason to believe that it is the result, partly of nervous influence, and in part of changes of a purely chemical nature[3].

We will now enter into the subject a little more in detail, by considering further the different species of sensation and muscular action: the former of these will detain us but a short time; but the intricacy and hitherto inexplicable nature of some parts of the latter will lead us to dwell longer on this division of our subject, in the hope of placing the student in possession of the recent valuable discoveries of an eminent physiologist of our own country, bearing on the point in question.

Sensation, as we have defined it, is divisible into two heads: 1. *Common sensation*, with its modification, the *sense of touch*; 2. *Specific sensation*, which comprehends the other *four senses*.

[1] These terms are used, not as synonymous with sympathetic, but in a more extended sense: for, as will by and by be shown, there is good reason to believe that all ganglionic nerves are nerves of assimilation. See the Appendix to this division.

[2] For further observations and references on this subject, see *Sympathetic System*. No further reference to *assimilation* will be necessary in the course of these remarks.

[3] The reader is referred to the experiments of Crawford, Brodie, and others.

These have their source in the cerebrum; and, as shown by Sir Charles Bell, are referable to a certain portion of the fifth cerebral nerve; and the posterior or ganglionic roots of the spinal nerves[4]. These, when pinched, produce evidence of suffering, but no muscular contractions: they may, however, be made the conducting medium for galvanism, which through them can excite muscular contraction. The nerves of *specific sensation* are the first, second, portio mollis of the seventh, and either (for it is far from a settled point) the lingual branch of the fifth or glosso-pharyngeal division of the eighth.

All normal *muscular action* is dependent on a

[4] It may be naturally asked, why exclude the pneumogastric nerve, for surely the lining membrane of the air-passages is highly sensible? The student must not fall into this error, to which his attention has already been directed. Highly *excitable* the larynx certainly is, but the distressing sensation which results from the introduction of a foreign body into the windpipe is produced by the excited condition of the mucous and muscular tissues, and the spasmodic efforts which occur, in part spontaneously, for the purpose of getting quit of the extraneous matter. Still, however, it must be acknowledged that some of these parts under a diseased condition are capable of transmitting sensation to the sensorium; and in health we all know that the upper part of the pharynx, palate, gums, &c. are sensible like the skin. This surely can only be explicable on the supposition that the lingual branch of the fifth is principally, if not *solely*, the nerve of sensation of these parts; particularly when we consider that of all parts, the tip of the tongue is endowed with the most delicate sense of touch; and this part is most largely supplied by the lingual branch of the fifth. But of this, more in its proper place.

reflex function possessed by the supplying nerves: or, in other words, under ordinary circumstances, it is requisite that the condition of a muscle should be made known to some nervous centre previous to the occurrence of the contraction, which can therefore only ensue as the consequence of reflected agency. This twofold action implies double intervening filaments between the corresponding nervous centre and the muscle. The nervous centres or axes may be the cerebrum, the true spinal marrow, or the sympathetic ganglia.

In some instances, this reflex influence may be substituted either by a stimulus *directly* applied to the nervous centre, or to the nerve in its course, *without* implicating the nervous centre: but these are anormal modes of excitement.

We are thus far anticipating the proper course of things by stating results before we give reasons; but it is in order to afford the reader a previous general view of the objects it is intended to develop. Frequent reference—with as little detail as possible—will be made to experimental evidence in support of the points proposed for consideration: where demonstration fails, analogical reasoning will aid us in our inferences, which in such case must partake more or less of a speculative character[1].

[1] The reader is again reminded of the necessity of not taking for granted the correctness of those opinions which have not received general sanction, but to read and judge for

Before entering upon the subject more at large, it will be necessary to say a few words on *muscular irritability*. This property of muscular fibre has been made the subject of much dispute amongst physiologists, some of whom have supposed it inherent, and inseparable from the tissue to which it belongs; and others, that it was dependent on nervous influence. Without examining the various arguments advanced by either party, we will merely state what appears to be the fact. We know that as long as the constituent materials of muscle retain their tone, (*i. e.* before they become rigid or decomposed,) so long will muscular fibre contract on the *direct* application of such a stimulus as galvanism, for example: but it by no means follows that the capability of being excited to contraction is inherent in the muscular fibre, independent of nerves. On the contrary, nervous matter is a necessary, universal, and inseparable constituent of muscle[2]: and as we know that the same effects may be produced by galvanism *with* the intervention of a nervous trunk, the inference is fair, that muscular irritability is dependent on the *presence* and *influence* of nervous matter[3].

himself. Many of the statements in the text may appear dogmatical; but this, it will be perceived, is an unavoidable consequence of conciseness.

[2] That is, as far as microscopic observation informs us, and it is quite consistent to infer as much as is stated.

[3] It is almost needless to notice that galvanism is only a

We now proceed to notice the different kinds of muscular action, with the centres to which they are severally referable; and first, of voluntary motion. This sort of motion is the result of *cerebral* influence which is communicated by nerves taking their origin from the brain within the skull, or from its prolongation within the spinal canal[1]. Reference to pathology will set this beyond doubt. In instances of compression of the brain, from depressed bone in fractured skull, an invariable concomitant symptom (if the case be well marked,) is total loss of voluntary power; this may be regained after the depressed bone has been raised, but not till then. When the spine is fractured and the marrow compressed, total loss of voluntary power is sustained below the seat of injury: but the lesion in these instances, when extensive, is of a more serious nature, and apparently irreparable by the means resorted to in the others[2].

substitute for the normal *influence*, whilst the necessity for nerves, as conductors, remains the same. The reader may consult an article on "the irritability of muscular fibre," which appeared in the Edinb. Med. and Surg. Journal a short time since, containing the results of the experiments and the opinions of Dr. Henry of Manchester.

[1] For the spinal cord, as it is commonly spoken of, can be considered as nothing else than an appendage of the brain, or, in other words, *a large nerve*.

[2] It has been observed (by Sir Charles Bell, I believe), that it is erroneous to conceive that the brain is compressible. This is probably correct; but the symptoms attendant upon depressed

Sir Charles Bell remarks, "It has hitherto been supposed that the office of a muscular nerve is only to carry out the mandate of the will, and to excite the muscle to action; but this betrays a very inaccurate knowledge of the action of the muscular system; for before the muscular system can be controlled under the influence of the will, there must be a consciousness or knowledge of the condition of the muscle[3]." This is incontrovertible: for instance, the consciousness of a state of flexion of the fingers is completely independent of sensation; and we should never think of stretching forth the hand in that condition to

bone are at any rate evidences of *pressure upon* the brain: nor are these symptoms explicable on the supposition that the pressure is confined to one spot, but should rather be referred to the whole cerebral mass. This also would result, for evident reasons, supposing the brain incompressible. Now as we know that there is nothing like a vacuum in the skull or spinal canal, when bone is driven in, some portion of the encephalic contents must occupy a more contracted space than they did in the normal condition. As it is presumed that the serous exhalation is incompressible, (or inappreciably so,) the only conclusion we can come to is, that less blood circulates through the brain under these circumstances; and this very diminution of supply, and the increased pressure of vascular action resulting from the diminished calibre of the vessels, both have a collateral tendency to keep up the state of coma. That children may have their cranial bones actually bent in and rendered concave, as one sees occasionally, with no symptoms of cerebral mischief, is probably referable to the power of adaptation between the comparatively yielding parietes and the viscus they surround.

[3] Bell's Anatomy, vol. ii. p. 392.

grasp an object, without first unclasping the fingers; and as soon as the brain has ascertained that the muscular fibre is in a condition ready for contraction, the mandate is issued by the will[1]. To quote further the same authority: "To the full operation of the muscular power, two distinct filaments of nerves are necessary, and that a circle is established between the sensorium and the muscle: that one filament or simple nerve carries the influence of the will towards the muscle, which nerve has no power to convey an impression backwards to the brain; and that another nerve connects the muscle with the brain, and acting as a sentient nerve, conveys the impression of the condition of the muscle to the mind, but has no operation in a direction outward from the brain towards the muscle, and does not, therefore, excite the muscle, however irritated[2]."

This then seems all that is necessary for the simple contraction of a voluntary muscle: but when a prolonged and continuous action is required, it appears essential that a more lively impression should be conveyed to the brain, and this is effected through the medium of the sentient nerves of the skin. There are many instances on record in which there was total loss of sensation, whilst muscular power remained unim-

[1] This is but a rude illustration of Sir Charles Bell's meaning, but it will answer the purpose.

[2] Bell's Anatomy, vol. ii. p. 392.

paired: in these cases, it was necessary for the individuals to keep constantly in sight any object which they wished to retain in the grasp, or it would soon escape and fall to the ground in consequence of the suspension of muscular action[3].

Therefore, the term 'reflex' is not inapplicable to this nervous circle. Yet we know that if the origin or any portion of one of these nerves be irritated, contraction of the muscle which it supplies will ensue; but this, as before stated, is the result of an anormal action, and of course completely independent of the will. Now, all we ask of the reader is to presuppose an *analogous mode* of influencing muscular fibre in the other systems we are about to speak of; but with these differences, that for the sensorium he substitutes another centre, and for volition another power, about which all our knowledge is negative, viz. that it is *not* the will: it need hardly be added, that these differences imply a distinct motive or incentive to action; the necessity of conveying the impression to the corresponding centre alone remaining the same.

We will now briefly lay before the reader an outline of the respiratory system as described by Sir Charles Bell, introductory to unfolding the more

[3] This subject has been illustrated by Mr. Mayo and Dr. Marshall Hall. Dr. Ley narrates an interesting case in point, in the *first volume of the Med. Gaz.* at page 755. Sir Charles Bell's remarks on this case will be found in the same volume.

comprehensive excito-motory system of Dr. Marshall Hall, under which head it will be shown that the former must be included.

The narration which Sir Charles Bell gives of his discoveries on this subject will be read with interest. After describing the course of his reflections on viewing the origin of certain nerves from a distinct column of the spinal marrow, he says, that a consideration of their distribution led to an inquiry into their function; and experimental investigation gave him the result, "that these nerves excite motions dependent on the act of respiration." This physiologist then proceeds to describe a convex strip of medullary matter descending between the corpus olivare and restiforme, and entitles it "the respiratory track:" and the nerves arising from it in succession from above downwards, "the respiratory nerves;" they are the *fourth*, the *portio dura* of the seventh, the *glosso-pharyngeal*[1], the *par vagum*, the *spinal accessory*; and lower down, and in all probability from a continuation of the same track, the *phrenic* and *external respiratory*. "It is probable," adds this author, after stating his inability to trace the respiratory track below the medulla oblongata, "that the branches of the intercostal and lumbar nerves, which influence the intercostal muscles and the muscles of the abdo-

[1] The reader is referred to the glosso-pharyngeal nerve for further discussion respecting its real function.

men in the act of respiration, are derived from the continuation of this same cord or slip of medullary matter." Again, in another place: "Under the class of respiratory motions we have to distinguish two kinds; first, the involuntary or instinctive; secondly, those which accompany an act of volition. We are unconscious of that state of alternation of activity and rest which characterizes the instinctive act of breathing in sleep; and this condition of activity of the respiratory organs we know, by experiment, is independent of the brain. But, on the other hand, we see that the act of respiration is sometimes an act of volition, intended to accomplish some other operation, as that of smelling or speaking."

We find, on reviewing these respiratory nerves, that they are not all distributed to muscles,—they are not all *immediately* agents in respiration. It is true, that by its extensive distribution the par vagum preserves the sympathy between the many organs which receive its branches; it is true, that more or less directly its laryngeal branches act as respiratory nerves: but wherefore the almost exclusive distribution of the large pulmonary plexus to the lining membrane of the air-passages and cells? We merely point to the question now, but will not anticipate the answer.

Let us examine further difficulties. Some physiologists have denied that respiration is an involuntary action; but surely it is paradoxical to state, "that a person labouring under apoplexy will *perceive* the uneasy sensations transmitted from the collapsed lung, and will *voluntarily* employ the muscles of respiration to relieve them *without* being at all conscious of such perceptions having occurred." The act in such case is *not* voluntary, but, as shown by Bell and others, is essentially independent of the seat of volition. It is of course not meant to imply that the act of respiration may not be influenced by the will; on the contrary, we know that as long as the functions of the cerebrum are unimpaired we are capable of performing various voluntary acts of respiration; but in apoplexy, or coma from other causes, when even the excitability of another system of nerves is at a low ebb, we have no coughing, no sneezing or sighing, in short, no evidence of aught else than a laboured and ill-organized process of respiration, the result of a modification of the causes that produce ordinary respiration. We conclude, then, that the respiratory act, under ordinary circumstances, is an involuntary act; but the agents require stimulating: how is this explained? The answer is simply this: the carbonic acid which the blood yields in the lungs, acts as an appropriate stimulus to the filaments of the pneumogastric nerves spread over the air-cells; that this excited condition is conveyed to the brain and thence reflected along the respiratory nerves of motion, which then perform their office of expanding the chest[1]. In short, it is an excited act, and requires a reflex action, having some portion of the medulla oblongata for its centre.

This difficulty being solved, we may now proceed to ask, does the respiratory system stand alone—is it solitary in these peculiarities? Attention to a few facts will answer this question, and prove that there exist many phenomena which are perfectly inexplicable, except we interpret them on principles analogous to those on which the respiratory system is grounded: in a word, we must conclude that there is a division of the medulla spinalis endowed with peculiar properties; that it is separate and independent of that portion which stands only in the relation of

[1] This is Dr. Hall's explanation: its truth can hardly be questioned. Experiments which were performed long since, and for other purposes, tend to prove its correctness. For instance, as long as artificial respiration is kept up, there is no effort at inspiration; but as soon as carbonic acid is allowed to collect in the lungs, the respiratory effort invariably follows. Dr. Alison says "that the motion of venous blood in the lungs gives rise to a sensation amounting quickly to extreme anxiety if not relieved, and uniformly prompting the complicated action of inspiration, by which it is immediately appeased." (Alison's Physiology, p. 139.) This, however, is not a sufficient explanation; for venous blood circulates through the lungs of animals in a state of hybernation, and yet there is no respiratory effort excited. It appears as if the actual elimination of carbonic acid were necessary, for the purpose of producing the requisite degree of excitement to be followed by the act of inspiration.

an appendage to the cerebrum, and as a conductor or propagator of the functions of which the latter is the source. The phenomena here alluded to are principally connected with the apertures of ingress and egress to and from the internal organs of the body, but also, though in a minor degree, with the tone of the general muscular system. We will narrate two experiments, as performed by Dr. Marshall Hall, in proof of these assertions, and then proceed to detail the component parts of this system[1].

"A horse was struck with the pole-axe over the anterior lobes of the brain. It fell instantly, as if struck with a thunderbolt; it was convulsed, and then remained motionless. It shortly began to breathe, and continued to breathe freely by the diaphragm. When lacerated or pricked by a *pin* or a *nail*, on any part of the face or surface of the body, it was totally motionless, manifesting no evidence of sensation or volition. When, on the

[1] These experiments, and the remarks which follow on this system, are compiled from the Lectures of Dr. Hall on the Nervous System, the use of which has been liberally permitted me by the author. Although necessarily indebted for all that is valuable in the observations on this division of the nervous system, to these lectures (now just published), or to the personal kindness of Dr. Hall in giving me all the information I asked, I by no means wish to make this gentleman answerable for the many imperfections and omissions which this scanty outline may contain. The opinions of Dr. Hall respecting the *nutritive functions* of the external ganglionic nerves will be noticed in a subsequent part of the text.

other hand, the *eyelash* was touched with a *straw*, the eyelid was forcibly closed by the action of the *orbicularis*. When the cornea was touched, the eyeball revolved outward by the action of the *abducens*. When the verge of the anus was touched, the sphincter contracted forcibly, the tail was raised, the vulva was drawn towards the anus[2].

"The upper part of the medulla oblongata was now destroyed by an instrument passed through the orifice made by the pole-axe: there were violent convulsions; the respiration ceased, and the eyelid and eyeball remained motionless on the application of stimuli."

Now, I imagine that it will not be disputed, that the blow of the pole-axe, in this case, annihilated the cerebral or sentient and voluntary functions; and that a peculiar set of excito-motory phenomena remained. Deep lacerations produced no evidence of the former; the touch of a straw induced a full manifestation of the latter. The destruction of the medulla oblongata removed all trace of excito-motory phenomena in the eyelid and eyeball."

"You observe this living frog; its sentient and voluntary functions are obvious. I divide the spinal marrow, below the occiput, with these

[2] I have had the satisfaction of performing this experiment in company with Dr. Hall.

scissors: all is still. There is not a trace of *spontaneous* motion. The animal would remain in this very form and position, without change, until *all* signs of vitality were extinct. But now I pinch a toe with the forceps. You see how both posterior extremities are moved. All is now still again; there is no spontaneous motion, no *sign of pain* from the wound made in the neck. It is without sensibility, without volition; the *power* to move remains—the *will* is extinct. I now pinch the integument. You observe the result—the immediate recurrence of excito-motory phenomena. I now destroy the whole spinal marrow with this probe. It is in vain that I pinch the toes; the animal, the limbs are motionless!"

"Could the former *excited* motions be those of irritability? I will try the truth of this suggestion by seeing whether, now that the axis of the excito-motory system is destroyed, with its phenomena, the application of a slight galvanic shock will prove the subsistence of irritability. You see how forcibly and instantaneously the muscles are stimulated to contraction. Is not the proof, from these experiments, of the distinction between the motions of volition, of the excito-motory system, and of these from those of irritability, perfectly and unequivocally complete[1]?"

[1] In some animals, as the eel, turtle, &c., the excito-motory system is more developed than in others, constituting what we often term "tenacity of life." Excito-motory phenomena are

CLASSIFICATION OF THE EXCITO-MOTORY SYSTEM.

This system necessarily consists of component parts which are analogous to those of the voluntary system, viz. a centre or axis, and double filaments, conveying impressions in opposite directions. The axis of the excito-motory nerves is the true spinal marrow, a structure, the existence of which is inferred; but its *separate* existence is not demonstrated. This latter further differs from the voluntary system, in "requiring always the application of an appropriate stimulus, or cause of excitement or irritation." The nerves along which the influence of the stimulus is carried to the spinal marrow, are the excitor nerves; and those along which this influence is conveyed in a reflex course to the muscles, the motor nerves. The axis of this system does not present any single or central point from which its influence is propagated, but each part receives its own impression and reflects its own influence, thus rendering independent the several individual component portions, which collectively obey the same laws and form a cooperating whole.

Let it be understood, however, that though each particle of the true spinal axis possesses the

more apparent in the lower orders of animals, and in the very young of the higher orders, and in animals in a state of hybernation.

essential property of independently receiving and reflecting an impression, so that if a portion of the spinal marrow were isolated by section above and below, it would still retain this power[1], nevertheless, whilst unimpaired by lesion, a distant part may receive a transmitted impression, and the reflected agency may be made apparent elsewhere: in this way, a respiratory effort may be induced by plunging the feet into cold water[2]. Again, a previous statement must not lead to the erroneous conclusion that the excito-motory and voluntary nerves cannot act conjointly: it is by no means intended to imply this; on the contrary, these systems may always and do frequently cooperate, as in certain conditions of respiration, the control over the sphincters, &c.; such cooperation producing a mixed function, which, "although generally belonging to the excito-motory system, is yet capable of being affected through the medium of volition."

[1] This, it may be remarked, approaches a step nearer to the properties supposed to be possessed by ganglia as motive agents —a link between these and the brain.

[2] Movements of the limbs are excited by pinching the nerves, as they leave the spine, with the forceps. Upon this well-known phenomenon Dr. Hall remarks, "The influence of this stimulus is not only *reflected* upon the limbs, but it is *retrograde* in its course, passing from a nerve proceeding from the middle part of the spine, *forwards* to the anterior, as well as backwards to the posterior extremities. This experiment appears to present us with the simplest type of some spasmodic diseases, and especially of traumatic tetanus."

The excitor and motor nerves of this system may run together, as in the limbs; or they may pass to their relative destinations separately from each other, and in conjunction with voluntary or sentient nerves, as in the head and chest.

The true Spinal or Excito-motory system.	Excitors.	Ganglionic portion of the Fifth.	The Eyelid. The Nostril. The Fauces. The Face.
		Pneumogastric.	The Larynx. The Pharynx. The Lungs. The Stomach.
		Posterior spinal roots.	The Anus. The Cervix Uteri. The general surface of the body.
	Motors.	Non-ganglionic portion of the Fifth.	The muscles of mastication.
		Seventh.	Orbicularis palpebratum.
		Fourth and Sixth.	The Eyeball.
		Pharyngeal and Laryngeal branches of the Pneumogastric.	The Pharynx. The Larynx.
		Hypoglossal, or Ninth.	The Tongue.
		Pneumogastric. Spinal accessory. Phrenic. External respiratory of Bell.	Muscles of Respiration.
		Anterior spinal roots.	Sphincters. Ejaculators. The Uterus. The Bladder? [2]. The Rectum? [2]. The general muscular system.

[2] I have placed a note of interrogation after these parts, because they are omitted in Dr. Marshall Hall's arrangement: I think it very probable that both these viscera, especially the former, may be influenced under certain conditions by the excito-motory system: the causes of incontinence of urine may frequently be traced to this; as in children who sleep on the

We now proceed to the further illustration and practical application of the above statements[1].

1. "Filaments of the fifth pair of nerves are the excitors distributed upon the border of the eyelid and surface of the eyeball,—upon the nostrils,—probably upon the fauces,—certainly upon the face,—and are the *first* agents in inducing closure of the eyelid, sneezing, vomiting, and sobbing, when the eyelid is touched, the nostrils stimulated, the fauces irritated, or cold water is dashed upon the face. Others, motor nerves, convey the reflex influence from the medulla oblongata to the orbicularis, and the various respiratory muscles whose actions are combined to the acts of sneezing, vomiting, and sobbing[2]."

back, when the trigone is irritated by pressure of the fluid; or in the instance of expulsion of the urine, as the result of placing the hand of a sleeping person in cold water. I am the more inclined to adopt this opinion, as I have omitted in the table any notice of the so-called *sphincter vesicæ*. I believe that the circular fibres about the neck of the bladder do not perform the office ascribed to them of retaining the urine. See some remarks on the *Bladder*, appended to the *Hypogastric plexus*.

[1] The paragraphs included between inverted commas are extracted *verbatim*, or nearly so, from Dr. Hall's Lectures.

[2] "In hemiplegia the loss of sensation is rarely complete, and there is usually paralysis of the muscles of the face, and the susceptibility of the nostrils to irritants is unimpaired...... The seventh comprises pure cerebral and true spinal nerves: the cerebral only is affected in hemiplegia, and the orbicularis retains its power; all are paralysed by the pressure of a tumor below the ear, and we have paralysis of the sphincter of the eyelid."—*Dr. Hall's Lectures, &c.*

2. "Filaments of the pneumogastric are the excitors, when carbonic acid gas or a drop of water comes into contact with the larynx[3],—when the dust of ipecacuanha is inhaled into the bronchia with the effect of inducing asthma,—in deglutition,—in ordinary respiration,—and in the act of vomiting produced by antimony in the stomach and calculi in the gall-duct or ureter[4]."

"If the fifth nerve in the fauces be irritated, vomiting is induced[5]: if, on the contrary, the

[3] In a case which occurred some years since at St. Thomas's Hospital, a strong man suffering from tetanus was plunged suddenly into cold water, and died almost immediately afterwards. The cause of death was most probably *excited* spasm of the muscles commanding the opening of the glottis. Indeed this appears to be the cause of death in most cases of this disease and of hydrophobia.

[4] "In spasmodic diseases, the orifices and exits of the frame are the parts principally affected. The *larynx* is *closed* in the convulsions of children, in epilepsy, in puerperal convulsion, in hysteria, in which there is frequently loss of voice, &c. The *pharynx* is affected in some of these diseases; the respiratory muscles are so in all.

"The condition of the larynx and of the respiratory motions affords an important diagnosis between epilepsy and hysteria. In the former, the larynx is usually closed with forcible expiratory efforts; in the latter it is open, with heaving, sighing breathing."—*Dr. Hall's Lectures, &c.*

[5] "Vomiting may be excited by disease within the cranium, by irritation of the fifth in the fauces,—of the pneumogastric in the stomach, the gall-duct, the ureter,—of spinal nerves of the cervix uteri. This familiar phenomenon combines the excitor nerves and motor nerves of respiration into one system. On the other hand, dentition may produce strangury and tenesmus,—symptoms of calculus,—which will cease on freely lancing the gums."—*Dr. Hall's Lectures, &c.*

eighth in the pharynx be excited, the act of swallowing follows."

The act of *Deglutition* is always an excited act: "it requires the presence of some stimulus, of some substance to be swallowed: it is impossible to perform the act of swallowing three or four times in rapid succession, without taking something into the mouth: the absence of an excitant annuls the act, which, if it take place at all, must be an excited act. Yet this very act was excited in the most distinct manner, in an experiment of M. Magendie, by passing the finger into the *pharynx* of a dog, through an incision made between the thyroid cartilage and os hyoides. A filament of the pneumogastric nerve is stimulated; the effect of this stimulus is conveyed to the medulla oblongata, reflected thence, and conveyed by appropriate motor nerves to the muscles of deglutition."

The act of ordinary *Respiration* is excited, the stimulus being "the contact of a certain proportion of carbonic acid with the filaments of the pneumogastric nerves in the lungs. Dr. Faraday particularly mentions the fact, that the respiration can be suspended longer after repeated deep inspirations, by which the air of the lungs is completely renewed, than in ordinary circumstances [1]; in Hook's celebrated experiment [2], a stream of

[1] Lond. and Edinb. Phil. Mag., vol. iii., 1833.

[2] See the Philosophical Transactions for 1667, p. 539.

atmospheric air was driven through the trachea, the lungs, and incisions made through the pleura in a living dog; the animal made no effort to inspire whilst this stream was continuous, but when it was interrupted the efforts of inspiration were violent and convulsive. In this manner we may understand the *impossibility* of suspending the respiration beyond a certain period. In this manner we understand why an animal dies convulsed from submersion under water if the pneumogastric nerves be entire, but without convulsions if they be divided."

The acts of ordinary respiration are, therefore, not spontaneous, nor is the medulla oblongata their source and '*primum mobile*,' but the centre or axis whither the excited impression tends, and whence the motive impulse is reflected. Nevertheless, these acts, as before stated, *may* emanate from the will: it is clear, then, that the medulla oblongata must consist of two distinct portions similar in their functions to the rest of the spinal cord; viz. one division, a prolongation from the brain; the other, the axis of the excito-motory system[3].

[3] The description of the phenomena presented in anencephalous fœtuses are most interesting as bearing on our subject generally. The cases of Mr. Lawrence, M. Lallemand, and M. Olivier are quoted by Dr. Hall. We give that of Mr. Lawrence, as illustrative of the object in view. "The child moved briskly at first, but remained quiet afterwards, except when the tumor was pressed, which occasioned general convulsions. It breathed naturally, and was not observed to be deficient in

Again, the pneumogastrics are not the only excitors of the respiratory act. Accordingly, as Dr. Alison observes, "The actions of respiration, although not stopped after section of these nerves, are yet in general performed slowly and always imperfectly[1]: and the experiments of Legallois and Flourens have shown unequivocally, that by injury of the part of the medulla oblongata, from which these nerves originate (and of that alone, of all the contents of the cranium), all attempts at inspiration are finally arrested[2]."

warmth, until its powers declined. I regret that, from a fear of alarming the mother, no attempt was made to see whether it would take the breast: a little food was given it by the hand. It voided urine twice in the first day, and once a day afterwards: it had three dark-coloured evacuations. The medulla spinalis was continued for about an inch above the foramen magnum, swelling into a small bulb, which formed the soft tumor on the basis of the skull. All the nerves, from the fifth to the ninth, were connected to this." (Medico-Chirurgical Transactions, vol. v. p. 166.) In this, as in all similar cases, as Dr. Hall remarks, "There was no indication of sensation; the child remained quiet after the first brisk movement; and no event is mentioned which could establish the existence of of voluntary motion, the acts of swallowing, and of the expulsion of the urine and fæces, with the functions of the larynx and of the sphincters, belonging distinctly to the excito-motory system." (Dr. Hall's Lectures, &c. See also Lallemand, *Observations Pathologiques*, &c., p. 86; and Olivier, *Traité de la Moëlle Epinière*, ed. 2. Paris, 1827, p. 155.)

[1] Brodie, Phil. Trans. 1812.

[2] Alison's Physiology, p. 139. Yet Olivier describes one case of anencephalous fœtus where the medulla oblongata was also wanting; it is, I believe, unique, and it will not do to theorize on one case. Life continued for six or eight hours. (*Traité de la Moëlle Epinière*, p. 155.)

Now it appears that the reason why respiration does not cease on division of the pneumogastric nerves is twofold, 1. because the act may be voluntary, 2. because it may be excited by other nerves. But removal of the cerebrum and division of the pneumogastric nerves, or—which amounts to the same thing—destruction of the medulla oblongata, is followed by cessation of the respiratory act: this proves, then, that the other excitors, independently of the pneumogastrics, are insufficient of themselves to maintain respiration; besides, even *their* functions are, for obvious reasons, materially interfered with by the above-mentioned lesion.

The other excitors alluded to are principally the fifth and posterior spinal roots. Their agency is evinced by dashing cold water on the face or body; an act of inspiration is thus produced. In like manner the laughter occasioned by tickling is an excited act[1]. Even the irrepressible cry which is instinctively uttered on the infliction of

[1] Every one who has had to treat a case of poisoning by opium is aware of the value attached to frequently dashing cold water in the face of the patient: its efficacy is attributed to its antidotal power against a sleep which is but the precursor of a fatal coma: nor is this incorrect; it is the truth, but not the whole truth. May not this be the explanation? The poisonous effect of opium is not confined to that portion of the pneumogastric nerves distributed to the stomach, but, by continuity, soon extends to the pulmonic divisions, which are thus paralysed or rendered incapable of receiving, and consequently of conveying to the brain the impression ordinarily excited by

severe and sudden pain would almost seem to belong to the same system.

"It is probable that, at birth, the respiration is first excited by the contact of the cold atmosphere with the filaments of the fifth and spinal nerves[1]."

the contact of carbonic acid with the extreme nervous filaments. The resources which remain for sustaining respiration are, as before stated, through the medium of the voluntary system or the other excitor nerves: the latter cannot perform their function unless stimulated, and volition must not be allowed to sleep. Frequent dashing of cold water in the face procures both these desirable objects; a convulsive inspiratory effort is each time excited, and the voluntary system is effectually roused. These phenomena are, however, otherwise explicable.

[1] This conjecture is not only interesting in itself, but may be made of great importance to the accoucheur. Dr. Hall's remarks upon the causes and treatment of asphyxia in new-born infants are so highly practical and useful, that there needs no apology for introducing them here at length.

"An infant is said to be *still-born*. You wait for the establishment of respiration, and this event does not take place. There is a general alarm. You will now, for the first time, see the value and importance, in a *practical* point of view, of the principles of the physiology and pathology of the nervous system which I have been teaching you. I have told you that *respiration* is an *excited* function; that it belongs to the excito-motory subdivision. In one word, then, all our efforts must be instantly made to *excite* respiration. Now what are the *channels* through which this act may be excited? What are the excitors of respiration?—the *fifth*, the *pneumogastric*, and the *spinal nerves*! The *fifth* pair of nerves must be excited by *forcibly* dashing cold water on the face,—by stimulating the nostrils by ammonia, snuff, pepper, or the point of a needle. The *spinal* nerves must be excited by *forcibly* dashing cold water on the thorax, the thighs; by tickling or stimulating

The conclusion, therefore, is, that respiration like all acts of the excito-motory class is a *mixed*

the sides, the soles of the feet, the verge of the anus. What the pneumogastric is, as the excitory nerve of respiration under ordinary circumstances, the fifth and the spinal nerves are in cases of asphyxia or suspended respiration. The means recommended for exciting respiration through these excitors, frequently induce a sudden act of inspiration which proves the first of the series so essential to animal life. But if these attempts to *excite* respiration through the fifth and spinal nerves fail, we must *imitate* this function by artificially distending the lungs, in the hope that, eventually, it may be excited through its wonted channel the *pneumogastric*. To effect this, the practitioner's lips are to be applied to those of the infant, interposing a fold of linen, and he is to propel the air from his own chest slowly and gradually into that of the infant, closing its nostrils, and gently pressing the trachea upon the œsophagus. The chest is then to be pressed, to induce a full expiration, and allowed to expand so as, if possible, to effect a degree of inspiration. But it is important in doing this that the practitioner himself should make *several deep* and *rapid* respirations, and finally a full inspiration. In this manner the air expelled from his lungs into those of the little patient will contain more oxygen and less carbonic acid, and consequently be more capable of exciting the dying embers of life. I base this suggestion on an interesting communication by Dr. Faraday in the London and Edinburgh Philosophical Magazine, vol. iii. p. 241, for October 1833. It is ascertained that respiration may be suspended longer, as in diving or in experiments, after such repeated forced respirations, than in ordinary circumstances, from the greater purity of the air in the lungs. If all these plans should be tried in vain, I strongly advise galvanic or electric shocks to be passed from the side of the neck to the pit of the stomach, or in the course of any of the *motor respiratory* nerves, and their appropriate muscles. No time should be lost in sending for a proper apparatus; but should the lapse of an hour, or even more, take place before it *can* be obtained, still it should be sent for and tried. When respiration is established, the *face* must *still* be freely exposed function: "it is cerebral," (i. e. if unexcited through the medium of the fifth and spinal nerves,) "when the pneumogastric nerves have been divided; it is purely excito-motory when the cerebrum has been removed: it is annihilated when *both* these influences have been subtracted, either by performing these two operations in *succession,* or *at once,* as in dividing the medulla oblongata, at the origin of the pneumogastric nerves."

The action of the sphincter ani and ejaculator urinæ are usually under the control of the excito-motory system, though both may be influ-

to the air, whilst the temperature of the limbs and body is carefully sustained. In the *midst* of these efforts it should, in the next place, be the office of two other individuals to maintain or restore the *temperature* of the little infant by gently, but constantly, pressing and rubbing its limbs between their warm hands, passing them upwards in the direction of the venous circulation. An enema of gruel, at 98° or 100°, or *higher*, with a little brandy should be administered. As soon as possible, a little warm liquid, as barley-water, at blood-heat, should be given by means of the proper bottle, furnished with leather or soft parchment. A tea-spoon must not be used for fear of choking. If the infant draws the liquid through its own lips by its own efforts there is no danger."

Dr. Hall then proceeds to make remarks on the frequency of relapses into a *secondary asphyxia*, by which previous efforts are rendered unavailing, and the patient is lost. "We should therefore watch our patient," he adds, "and be prepared with all our remedies. We should dash cold water on the face occasionally, and expose the face of the patient to the cool, free, open air; and we should enjoin, in an adult, frequent full respirations."

enced by the will. The ordinary condition of the sphincter ani is a remarkable instance of tonic muscular contraction dependent on the excito-motory influence; and it seems more than probable that the accelerator urinæ is in a somewhat similar condition, and exercises an analogous function in relation to the urethra, the action of this last muscle being usually very restricted (in consequence of the existence of other obstacles to the escape of urine), though probably increased by the necessity for the exercise of its function by the stimulus of the *vis à tergo*[1]. The source of the power of this muscle as an ejaculator both of the urine and semen is less questionable; for, although capable of being controlled by the will, there can be little doubt that such action is usually the result of excitement: e. g. the moment the seminal fluid, &c., is poured into the urethra it is ejected spasmodically, and the effort

[1] This is certainly evidenced in the acts of coughing or sneezing: the contraction of the abdominal muscles and resulting pressure on the bladder would render the escape of urine a probable consequence, did not the spontaneous contraction of the accelerator urinæ close the bulbous portion of the canal. What the analogous muscle in the female human bladder or urethra may be, I am not yet prepared to state. My dissections of these parts in the mare, cow, sheep, &c., have been satisfactory; and I am still engaged in prosecuting the subject. The accelerator is highly irritable, and continues acting at intervals for a considerable period after death, even without being stimulated.

is irresistible, and therefore purely involuntary[1]. Neither does this take place without the excitement produced by the presence of the stimulus; and every one is aware that if the last drops of urine be not expelled by *voluntary* action, the *excited* action cannot be long deferred. A more tonic contraction of this and the sphincter ani results from the application of increased *local* stimulus; whereas the contrary would rather appear to be the case when the excitor nerves of the skin are stimulated[2].

It is well known that there is a constant, uniform, and more or less *tonic state of contraction*

[1] The influence which the excito-motory system exercises over this act is evidenced by a fact mentioned by M. Brachet in his *Recherches du Système Nerveux Ganglionaire*: "a patient, perfectly paraplegic, and destitute of all sensation below the loins, became a father." Moreover, the semen is occasionally expelled in epilepsy, in death from hanging, &c.

[2] I acknowledge that I think the instances of evacuating the bladder or rectum, when cold water is dashed on the skin, is rather referable to excited contraction of the muscular coats of these viscera whilst the sphincter and ejaculator remain *unexcited*. Many pathological phenomena are inexplicable, except by supposing that these organs may, under certain conditions, be under the influence of the excito-motory system: such influence is probably feeble and rarely excited. Much may no doubt be referred to the spasmodic contraction of the abdominal muscles. It may, however, be here remarked that sudden and forcible contraction of the abdominal muscles is *necessarily* (and not voluntarily) accompanied by action of the two muscles about the urethra and anus; thus are they linked to the respiratory apparatus. Paralysis of the bladder may ensue from the action of a tobacco enema.

of the whole *muscular system*. This is evidenced by destroying the equilibrium, for example, between the flexors and extensors of the fore-arm or fingers; the uninjured muscles have full and undisturbed sway when the opposing power of their antagonists is annulled; and hence the deformities resulting from division of important tendons. This property seems to be independent of the brain, and therefore, no doubt, has its source in the true spinal marrow, and is a phenomenon belonging to the excito-motory system. Thus the limbs of an animal, or of a part of an animal separated from the influence of the cerebrum, become relaxed on destroying the spinal marrow. These and the preceding remarks will be illustrated by the detail of some interesting experiments on the turtle, which will be given in Dr. Hall's words[3].

"A turtle was decapitated in the manner usual with cooks, by means of a knife, which divided the second or third vertebra. The head being placed upon the table for observation, it was first remarked that the mouth opened and shut, and that the submaxillary integuments ascended and descended, alternately, from time to time, replacing the acts of respiration. I now touched the eye or eyelid with a probe: it was immediately closed; the other eye closed simultaneously. I

[3] These will be found in the Philosophical Transactions for 1833.

then touched the nostril with the probe: the mouth was immediately opened widely, and the submaxillary membranes descended. This effect was especially induced on touching the nasal fringes situated just within the anterior part of the maxilla. I passed the probe up the trachea, and touched the larynx. This was immediately followed by a forcible convulsive contraction of the muscles annexed to it. Having made and repeated these observations, I gently withdrew the medulla and brain. All the phenomena ceased from that moment. The eye, the nostrils, the larynx, were stimulated, but no movement followed[1].

"The next observations were made upon the other parts of the animal. The limbs, the tail, were stimulated by a pointed instrument or a lighted taper. They were immediately moved with rapidity. The sphincter was perfectly circular and closed; it was contracted still more

[1] It will probably strike the reader that many, if not all, the phenomena noticed by those who have made observations on the subject of decapitation are explicable on the principles deduced from these and similar experiments narrated in the text. It is singular to remark, in the discussions which have given rise to various opinions upon the probability of the severed head retaining its sensibility and power of willing an action, how little attention has been paid to the effects which must result from removing the *pressure* of the double column of blood, which is necessary to preserve the brain from a condition of syncope. The profession is indebted to Dr. Marshall Hall for having first directed attention to this fact.

forcibly on the application of a stimulus. The limbs and the tail possessed a certain degree of firmness or tone, recoiled on being drawn from their position, and moved with energy on the application of the stimulus. On withdrawing the spinal marrow gently out of its canal, all these phenomena ceased. The limbs were no longer obedient to stimuli, and became perfectly flaccid, having lost all their resilience[2]. The sphincter lost its circular form and its contracted state, becoming lax, flaccid, and shapeless. The tail was flaccid, and unmoved on the application of stimuli.

"This experiment affords evidence of many important facts in physiology. It proves that the presence of the medulla oblongata and spinalis is necessary to the contractile function of the eye-lids, the submaxillary textures, the larynx, the sphincters, the limbs, the tail, on the application of stimuli to the cutaneous surfaces or mucous membranes. It proves the excited reflex character of this property of the medulla oblongata and spinalis. It proves that the tone of the limbs, and the contractile property of the sphinc-

[2] I may add to this a fact noticed by those who have witnessed executions by the guillotine: the features of the face, whose expression is, I believe, invariably tranquil and composed, retain their firmness, and do not become flaccid for a considerable period: the jaw does not drop, neither do the eye-lids droop. These phenomena are doubtless referable to the excito-motory system.

ter, depend upon the same function of the medulla spinalis,—effects not hitherto suspected by physiologists.

"I must now state that the phenomena which have been detailed, subsist in distinct portions of the medulla. If, after severing the head of the turtle, the lower extremities and the tail be separated together, in the manner usual with cooks, the phenomena which I have described are still observed in the distinct and separate portions of the animal. The head, the anterior extremities and the tail, present the movements which have been described, when severally stimulated. The posterior extremities alone were observed to be flaccid and unimpressible by stimuli; and these were found, on examination, to have been separated from their connexion with the spinal marrow.

"An interesting experiment demonstrates the powerful influence of the spinal marrow over the sphincter ani in the turtle. If, after the removal of the tail and the posterior extremities, with the rectum, and of course with a portion of the spinal marrow, water be forced into the intestine by means of Read's syringe, both the cloaca and the bladder are fully distended before any part of the fluid escapes through the sphincter, which it then does on the use of much force only, and by jerks. The event is very different on withdrawing the spinal marrow: the sphincter being now relaxed, the water flows through it at once in an easy continuous stream, with the application of little force, and without inducing any distension, even of the cloaca[1]."

[1] We shall here quote the remarks of Dr. Marshall Hall upon some of the most prominent diseases of the excito-motory system: many of these observations are of equal, and even greater importance to the surgeon than the physician. "I believe," says this author, "that the *whole* order of spasmodic and convulsive diseases belongs to this, the excito-motory division of the nervous system,—and that they cannot be understood without a previous accurate knowledge of this system. Another remark is equally important. *All* these diseases have their source in *one* of three parts of the excito-motory system: the *first* series have their origin in the spinal marrow itself, the axis or centre of the system: the *second* series have their source in the excitor nerves, consequently at a distance from that centre: a *third* series occurs, like the spasmodic of the seventh pair, in the course of the motor nerve. The *first* series, which may be designated *centric* diseases, are, for the most part, incurable; the *eccentric* diseases, which include the *second* and *third*, as generally, with some particular exceptions, admit of cure.

"A terrible disease of this order is *tetanus*. All the symptoms of tetanus sometimes arise from disease within the spine. This ought to be termed *centric* tetanus. Far more frequently the cause is seated externally, in the course of some of the excitor nerves of the system. A nerve included in a ligature, or lacerated in a wound, may prove the *eccentric* seat of tetanus. In both cases it is plain that it is the excito-motory division of the nervous system which is involved in the disease."

The same remarks are applicable to *Hydrophobia*. "But consider how this disease is induced; what symptoms present themselves; what parts, what functions, are involved; and you cannot fail to fix upon the particular division of the nervous system affected in this most terrible of maladies."

"No disease can illustrate the pathology of the excito-motory system better than *epilepsy*. It is sometimes *centric*, and in-

In the course of the physiological remarks which the reader will meet with in this work,

curable; frequently *eccentric*, arising from gastric or intestinal irritations, and curable. It involves every part, and every function, spoken of under the head of the physiology. The fourth and sixth nerves are affected, and the eyes move convulsively; the tongue is protruded, the teeth are forcibly closed upon it, the mouth is variously moved, with the extrusion of bloody foam; the larynx is closed, and there are forcible convulsive efforts of the expiratory muscles; and, as previously stated, the sphincters are sometimes relaxed, and the ejaculators occasionally expel the semen."

Hysteria, again, with its numberless varieties of character and symptoms, is no less a morbid condition of the excito-motory system; but, as elsewhere noticed, the condition of the larynx, and of the respiratory motions, affords an important diagnosis between epilepsy and hysteria.

Lastly, "the passions possess a singular influence over *all* the functions of the excito-motory system. Sickness, panting, convulsions, relaxation of the sphincters; these, and a thousand other affections of this system, are induced through the mysterious influence of disgust, fear, &c. Infantile convulsions and epilepsy are renewed by vexation, &c. (*Dr. Hall's Lectures, &c.*)

The following abstract of the *Therapeutics of the Excito-motory System* may be acceptable to the student.

"Strychnine obviously excites this system; whilst the hydrocyanic acid as obviously diminishes its powers. These two remedies may therefore have appropriate applications. . . . .

"The carbonate of iron, and the liquor arsenici are other remedies, the powers of which are only partially explored. They cure chorea.

"Then we have an important remedy in electricity and galvanism.

"Another important remedy, in the class of true spinal affections, is the dashing of cold water on the face, or surface. This remedy tends to open the larynx in epilepsy, and to convert the violent *expiratory* struggles into acts of inspiration.

"Another agent, which has great influence upon the excitoendeavours are made, by frequent allusions, to direct attention to the many and intimate links by which the different divisions of the nervous system are bound together: and the consideration of this last and very interesting portion of our subject would be incomplete without pointing out the connexion, nay, the mutual dependence, between it and the voluntary system, involving, as it does, the due performance of the functions of both. Nor can this be done with more advantage than by further quoting the highly practical remarks of Dr. Hall.

"However distinct," says this author, "the cerebral and true spinal subdivisions may be, they exert an influence upon each other which is essential to the well-being of the individual. The anencephalous fœtus, though it may be born

motory system, is change of air; this is observed in the later stages of pertussis, the croup-like convulsion, &c.

"Another view of this subject, and a most important one, is the removal of all the *causes* of morbidly excited states of this system. In the convulsions of infants we remove the causes of irritation in the gums, the stomach, the bowels, &c.; and in epilepsy of adults, we adopt similar plans.

"May not counter-irritation be applied more extensively along the spine than hitherto? . . . . . . Might not a lotion of the hydrocyanic acid be applied with advantage in some cases of *tonic* spasm? Might not the inhalation of the vapour of this powerful remedy be of service in some spasmodic affections of the respiration, &c.?" (Dr. Hall's Lectures, &c.) For further information connected with this subject, the reader is referred to a note a few pages back, respecting the *mode of restoring infants from a state of asphyxia.*

alive, and even live for some hours, is not *viable*; it must *soon* die. Apoplexy and hydrocephalus destroy the patient by destroying the cerebral functions merely. During sleep even, although this be *chiefly* an affection of the brain, the functions of the true spinal marrow are somewhat impaired; the respiration is noisy, frequently slightly stertorous, and irregular. Yet the respiration does proceed, acts of deglutition take place, and the sphincters do their office. Still a marked distinction between the cerebral and the true spinal functions is, that the former are partly suspended in *sleep*, and entirely in *coma*, whilst the latter are unimpaired: in sleep and in coma the eyelash is susceptible to the slightest stimulus; and the orbicularis, the sphincter of the eyelid, and the other sphincters, with the muscles of the larynx and of respiration, do their office. This state of things cannot last long, however, in coma; because the integrity of the cerebral functions is essential to the continuance of the true spinal, and the other functions, of the animal economy. Hence the fatal omen attached to stertor, choking, relaxation of the sphincters, and other morbid affections of the true spinal functions, in cases of cerebral disease, &c.

" On the other hand, if the excito-motory system be impaired in its fuuctions, the acts of the cerebrum are interrupted. The volition is perfect in chorea, in stammering; but the voluntary movements, from the morbid condition of the excito-motory system, are irregular and imperfect.

OF MUSCULAR ACTIONS, THE NERVOUS SOURCE OF WHICH ARE THE SYMPATHETIC GANGLIA[1].

The present division of our subject will occupy but a short time, as there is more of hypothesis, and less of practical utility connected with it.

The arguments which favour the supposition that there are certain portions of the muscular system under the control of the sympathetic ganglia, are negative rather than positive, and may be comprised under the following heads: 1. One division of the nervous system possesses the property of endowing muscles with the power of contracting, subject to volition; voluntary motion ceases when the brain is removed: it is therefore inferred that the brain is the source of voluntary motion. 2. Experiment proves, however, that after such subtraction, muscles still possess their tone, and are capable of contracting when certain stimuli are applied, directly or mediately, to the nerves supplying them: these phenomena also cease (with certain exceptions,) when the spinal marrow is withdrawn:

[1] The other functions of the sympathetic system are treated of in the course of the anatomical description.

the inference is, that some portion of the spinal marrow is the axis or centre of *excited* acts of contraction[1]. 3. The exceptions alluded to are, the heart, and arterial system; the stomach, the small intestines, and the large intestines. The muscular fibres of these organs continue, (with certain provisions,) to contract with vigour and regularity, after both brain and spinal marrow are removed; or, which amounts to the same thing, after they themselves are separated from the body. 4. It may be assumed, if reasoning by analogy be allowed, that the excitability of these muscles is dependent on the presence and influence of nervous matter; and the necessary deduction from the facts above stated, is, that this nervous matter has its source neither in the brain nor spinal marrow. 5. There are no other nerves remaining, but those originating from the sympathetic ganglia: if, therefore, our premises be correct, the inference is palpable, *that the susceptibility of being stimulated to active contraction, possessed by the above-mentioned organs, is a property derived from branches of the*

[1] Allusion is here made to phenomena which are evidently resulting from certain normal conditions of the system, a combination of which is necessary to the production of particular effects; implying, in short, the existence of intermediate agents and appropriate centres. This of course excludes phenomena dependent on the application of *anormal* stimuli, as the contraction of a muscle caused by pinching the supplying nerve, &c.

sympathetic ganglia distributed to their muscular fibres.

The collateral evidence which tends to support this hypothesis may be thus stated. 1. The heart and large arteries, and the principal portion of the alimentary canal, receive more ganglionic than other nerves. 2. It is requisite, since these organs are so essential to life, that there should be effectual means for preserving their functions from impairment or annihilation by sudden shock or limited local injury: this object is in great measure gained by the extended diffusion of the source of their nervous influence[2]. 3. It is important—for the same arguments that apply to the respiratory muscles—that the action of these organs should not be subject to volition; and further, their liability to frequent derangement, if governed by the same laws as muscles supplied by the excito-motory nerves, is a reason for excluding them from this system.

These may or may not be considered sufficient grounds for believing that the muscular contractility of these viscera is under the control of the sympathetic system: if true, it is not improbable, although purely hypothetical, that the "modus operandi" of this system is analogous to that of

[2] The properties of the diffused or smaller ganglia seem, *in a measure*, independent of the large central ganglia: the latter may generally superintend, or regulate the functions of the former.

the cerebral and true spinal; viz. that the ganglia, (which, it can hardly be questioned, exist where the eye cannot detect them,) stand in the relation of *axes* or *centres* to their *ultimate filaments,* which form the conducting and reflecting media between them and the muscular fibre they supply[1].

The muscles of this class only act when excited, and an important stimulus to them is distension. Their vascular organization is similar to that of other muscles, and they are therefore in like manner dependent on their supply of blood for a permanent continuance of their irritability[2].

We find then, as regards *motion,* that these three divisions of the nervous system are not abruptly separated from each other in the nature of their functions; but that the excito-motory division holds the position of a link or step between the purely animal or voluntary, and the purely vital or organic divisions. The centre of the *voluntary* system is most aggregated or circumscribed; that of the *excito-motory* system more extended, and its individual component portions less mutually dependent; the source of *gan-*

[1] Winslow was, I believe, the first physiologist who entertained the idea of the ganglia being separate and independent sources of nervous influence.

[2] Thus, the action of the heart, after it has been removed from the body, may be protracted much longer, if the circulation through the coronary vessels be maintained.

glionic influence is most diffused, and therefore, as a mass, less obnoxious to serious injury. The *excito-motory* system alone supplies organs, the muscles of which *may* be influenced by volition, but *usually* act independently of it: whereas the will *cannot* control directly the circulating and digestive actions.

It were almost needless here to point out the adaptation of these means to the ends required,—the wise purposes answered by the arrangements above indicated. If, to select a mixed function, we consider with attention the disastrous results which must ensue,—nay, the impossibility of protracting life for any lengthened period, were the respiratory muscles either purely involuntary, or solely controlled by the will, enough will be seen to warrant this assertion: nor will it be denied, it is hoped, that the leading features of the scheme here adopted have been framed on principles not wholly unscientific.

We shall dismiss the subject with an observation upon the relative liability to fatigue of the different classes of muscular fibre; and the progressive death of the three divisions of the nervous system.

It is well known that voluntary muscular action cannot be continued for any length of time, without an interval of rest: so also the respiratory muscles, when acting in obedience to the will, are subject to fatigue: but ordinary respiration, and the heart's action continue unceasingly from the cradle to the grave; nor does the peristaltic action of the alimentary canal enjoy much tranquillity. It is, however, probably an error to suppose that even these organs are *totally* exempt from the common law, by which nature requires that toil should be followed by repose, in order to a renewal of vigour. We may rest the voluntary muscles, but it is vain to seek refreshment without sleep: with sleep commences a slower and a gentler respiration; then is vascular action lowered, and the heart ceases to propel its blood with the same force it exerted during waking; even digestion is but ill performed during sleep, and this may in part arise from a tardy peristaltic action[1]. But perception, or ordinary sensibility to external objects, by which we ascertain what is going on around us, may be suspended, and still the involuntary systems be excited to the full: hence, the unrefreshing sleep of the restless dreamer or somnambulist[2].

When life is closing, in what order do the three divisions of the nervous system cease to exercise their influence on the frame?—and what constitutes what we call *death?* In the majority

[1] It is true that the carnivorous animal will sleep during the process of digestion: this, however, is not the case with the graminivorous class, in which more active peristaltic action is required.

[2] Of course this is partly attributable to the activity of the brain and senses.

of instances, where the powers of life ebb slowly, the cerebro-spinal centre is the first to relax its hold,—the extinction of volition and sensation is probably synchronous: next the excito-motory axis yields, and with it respiration ceases. In the ordinary acceptation of the term, *death* is now complete,—the body possesses neither animation nor excitability: but has the influence of the nervous system been altogether withdrawn? *Facts* will answer this question in the negative, and seem to point to the sympathetic as that division which survives the rest. We have already had occasion to direct attention to the longer duration of excitability in the muscular fibre of the vascular system and membranous chylopoietic viscera; and we have authentic instances on record, proving that secretion is not totally suspended when death supervenes; indeed, one cannot but suspect that even animal heat is generated, or at any rate retained in an extraordinary manner, after animal life is extinct. That all these phenomena, particularly muscular irritability, *soon* cease, is sufficiently explained by the consideration that, however independent in the *distribution of its influence*, the sympathetic system is materially dependent on the co-operation of other agents for its *capability of performing its functions*: the circle is broken,—the reaction of one system upon another is lost,—the mutual relation between cause and effect is destroyed:

no wonder, then, that annihilation of the organic functions is a speedy consequence, when animal life has ceased to be[1].

APPENDIX TO THE PHYSIOLOGICAL SECTION.

If all that has been said in the previous pages be true, and it seems probable that *most* of it is so, though we are far from desirous of dogmatically asserting even that much—the following axioms must be admitted, in reference to the division and functions of different parts of the nervous system[2]:

1. That the cerebrum is a single and independent centre of nervous influence.

2. That the medulla spinalis consists of two

[1] Richerand mentions a curious case of a young man who sweated profusely after death, &c. I have often been surprised, when opening bodies in the hospital dead-house, to remark how long they will sometimes retain their heat, whilst lying in a shell on the cold stone floor, perhaps in the depth of winter. Surely nervous influence must have something to do with this?

[2] These axioms will be frequently referred to in the course of the work, particularly in describing the functions of the different nerves: therefore, the reader is begged to pay attention to them, and to understand once for all that they are not dogmas, but merely comprehend a concise view of our still imperfect knowledge of the physiology of the nervous system. A repetition of this statement in the body of the work would be tedious and useless.

essential portions;—*a.* the spinal marrow commonly so called, being merely a prolongation or appendage of the cerebrum, to which its properties or functions are referable, and to which, in short, it bears the same relation as a large compound nerve: *b.* and the *true spinal marrow,* (not demonstrated,) the source of a separate and independent influence.

3. That the sympathetic ganglia are several and, to a certain extent, *individually* independent centres of nervous influence, but *completely* independent of the cerebral or spinal axes[3].

4. That the nerves of *volition* and *sensation* have their *origin* in the cerebrum and medulla spinalis; but that the *source* of voluntary power and sensibility is solely in the cerebrum.

5. That the *anterior* columns of the medulla spinalis transmit *motive power* to the derived nervous filaments, and the *posterior* columns endow the corresponding nervous roots with sensation.

6. That there is a series of nervous filaments which have for their centre and the source of their motive properties, the "true spinal marrow"; and that these are excited to a performance of their functions in an indirect manner,—viz. by means of impressions caused by the appli-

[3] Of course, the term "independent" has not an unlimited signification, being applicable only to properties possessed, and not to the due and perfect performance of functions: in this, as frequently indicated, each system is *dependent* on the others.

cation of appropriate stimuli to the extremities of another set of filaments belonging to the same system, producing in this way a reflex effect.

7. That this system comprehends the respiratory nerves of Sir Charles Bell.

8. That, lastly, there is a system of nerves which controls the purely *involuntary* motions;—by which is meant, actions analogous to those of the excito-motory system, but under the control of the sympathetic, and of which the ganglia of the sympathetic are the several centres of reflexion: and that these ganglia and their branches also control the different processes of assimilation[1].

[1] The above summary applies to the *normal* performance of the various nervous functions: the reader need scarcely be reminded that *anormal* stimuli, whose *modus operandi* is of course different, produce frequently similar effects. I was rather struck with a late experiment I performed, to remark how long, under ordinary circumstances, muscular fibre would contract on the application of anormal stimuli. Having procured the amputated limb of a healthy man who was admitted into the hospital for compound fracture of the leg, I found that by plunging an instrument into any portion of the muscle, a distinct, firm, and to a certain extent protracted, contraction ensued. The posterior tibial nerve was then pinched, and a distinct flexion of the toes resulted. In these phenomena there was nothing particular; but I was a little surprised to find that nearly if not full half an hour elapsed before they completely ceased; and that if the nerve was pinched often, the muscular fibre did not answer the stimulus, but that a certain interval of rest for the collection of fresh energy appeared necessary, which interval became more protracted as the evidences of vitality receded. No artificial means were employed to retain the heat of the limb.

Allusions have been made in different places to a supposition that all ganglionic nerves possess certain properties in common; or, in other words, that the branches of the sympathetic are not the *sole* nerves of nutrition, but that all the other ganglionic nerves, comprising the *portio major* of the *fifth*, the *pneumogastric*, and *posterior roots* of the spinal nerves, also direct and control the nutrition, growth, &c. of the parts to which they are distributed. These properties are supposed, moreover, to reside in the *ganglia*, and to be independent of the brain and spinal cord as centres.

The reasons in support of this hypothesis may be thus stated in the words of Dr. Marshall Hall.

"1. There is no connexion between the function of sensation and the existence of a ganglion; and the unequivocal sentient nerves, as the olfactory, optic, auditory, are without anything very distinct of this kind.

"2. There is an internal nerve for formation, nutrition, secretion, &c., and this nerve is ganglionic. There are external organs and structures requiring nutrition, &c., and there are also external ganglionic nerves. The inference is plain, that these constitute the external ganglionic subsystem. The fifth especially abounds with ganglia.

"3. It is true that the semilunar and external spinal ganglia differ in appearance from the ganglia of the sympathetic, as Sir Charles Bell has well displayed. What is the nature of this difference? It is plain that the difference consists in their being, alone, *plexic*. The internal ganglionic nerve is purely nutrient: its ganglia are simple. The external involve sentient, and I believe excitory, nerves, with the nutrient; they combine, therefore, the appearances of the plexus and of the ganglion.

"I must add another argument upon this point. If the sensation of the face be lost by paralysis, arising from disease of the *brain*, the eye is safe; but if the same event occur from compression or destruction of the *fifth*, *within* the cranium, by disease, or in an experiment, the eye ceases to be nourished and becomes destroyed! In the former case the nerve of sensation merely has suffered; in the latter, the nerve of nutrition, as well as sensation, has been involved in the disease or injury[1]."

The reader may be further reminded, that the sympathetic filaments cannot be traced along the limbs, &c.; it is merely hypothetical that they accompany the arteries to their terminations.

The interesting experiments of Sir B. Brodie, in which wounds were healed, fractured bones united, and nails grew, after division of the great nervous trunks, can hardly be quoted as milita-

[1] Hall's Lectures on the Nervous System, p. 30.

ting against one opinion more than the other: and in paralysis, partial or total, the disease will probably only affect the centre without interfering with the ganglia.

It will be seen, then, that this hypothesis must not be rejected without some consideration. The subject is one of considerable physiological interest, but not invested with sufficient practical importance to warrant a further inquiry in these pages.

No mention has been made in the preceding pages respecting the probable part the cerebellum plays in the various phenomena alluded to: the reason for such intentional omission is, that the opinions entertained upon the subject are of a more conjectural character, and less clearly substantiated by the unequivocal testimony which the unvarying results of experiments bear, than the connexion between other portions of the encephalon and the functions ascribed to them, have admitted of. We do not allude to the improbable hypothesis that the cerebellum is the seat, principally, of the *sexual* passion; pathology, at the least, rarely fails to prove that there is no necessary connexion between an excited condition of the organs of generation and this division of the encephalon: but reference is made to the control which it exercises over certain functions which emanate from the cerebrum.

Experiment leaves little room to doubt that the cerebellum is in no way connected with sensation; nor does its destruction (other parts being preserved entire) annihilate, or indeed, as far as we may judge, interfere with the power of willing an action. There is still, however, some agent required to superintend and *combine* the different muscular exertions, the cooperation of which is essential to the production of any given effect, such as an act of locomotion: this property appears to be lost on removal of the cerebellum, and the connexion between the agent and the effect is thus supposed to be established. We will, however, give the inferences which Flourens deduced from his experiments in his own words; recommending to the student, in the mean time, a careful perusal of this part and the rest of his interesting work on the functions of the nervous system.

After describing how removal of the cerebral lobes annihilates all voluntary power, this author proceeds thus: "An animal deprived of his cerebellum, loses all equilibrium, all *coordination*, all reciprocal relation [*corrélation*] in his movements. Nevertheless all the parts of such an animal, the head, the trunk, the extremities, all the parts, I say, move, and move with vigour; but since there is no longer any concurrence, any disposition, or *mutual understanding*, if one may venture so to express it, there is no result obtained. Such an animal as this no longer walks, no longer flies, no longer preserves the standing posture; not that he has lost the use of his feet or his wings, but because the combining and directing principle of his legs and his wings no longer exists. In a word, all the partial [or individual] movements are continued; the combination [*coordination*] alone of these movements is lost[1]."

It remains for us here to notice certain phenomena connected with the muscular structures of the eye and ear; to point out the striking analogy between them; and to show how the mode by which their action is influenced differs from that of the systems already described in the foregoing pages.

1. The analogy alluded to between the two organs consists in the following points:—*a.* each organ is supplied by a nerve of specific sensation; —*b.* there is a muscular structure connected with each organ, the use of which is to modify by its action the effects of external impressions;—*c.* this muscular structure is in each case supplied by filaments emanating from a ganglion[2];—*d.* the ac-

[1] *Recherches expérimentales sur les Propriétés et les Fonctions du Système Nerveux*; par P. Flourens. Paris, 1824, p. 211. The reader is also recommended to consult the *Anatomie des Systèmes Nerveux, &c.*, par F. Magendie et A. Desmoulins. Paris, 1825.

[2] The otic ganglion in the one instance; in the other, the

tion of this muscular structure in each organ is involuntary under ordinary circumstances[1]; and the mode in which it is stimulated in either instance is through the medium of an *appropriate reflected impression*;—*e.* that some portion of the encephalon, not necessarily the sensorium[2], is the centre of reflexion. The muscular structures alluded to are, in the eye, the iris; in the ear, the muscles of the malleus and stapes, which act mediately on the membrana tympani. The appropriate impressions are, in the one instance the vibration of the atmospheric air in the other the undulation of a more attenuated medium; producing on the sensorium the phenomena we term "sound" and "light".

2. The peculiarities which distinguish the muscles under consideration are, *a.* that the excitor nerve is also a nerve of specific sensation, *i. e.* that the filaments must be mixed;—*b.* that the motor filaments are derived from ganglia.

These are the facts connected with these curious points. We do not venture to draw any

ophthalmic or lenticular. The reader is referred to a description of these.

[1] Probably altogether so: for though there are instances in which the pupil may be contracted or dilated, apparently at will, yet such power is only mediate, and not direct.

[2] This is at any rate the case with the eye; perfect blindness from cerebral mischief may exist, without impairment of activity of the iris. Probably the tubercula quadrigemina or neighbourhood is the centre of each.

conclusions, but merely indicate, particularly with respect to the ear, the difficulty of tracing the channel (if our surmise be correct) by which the impression could be reflected upon the nerves supplying the muscles.

Note. The hypothesis respecting the function of the cerebellum, mentioned in the last page, has received support from the recent dissections of Mr. Solly, who has shown that some of the fibres which compose the *anterior* columns of the spinal marrow may be traced up into the medullary structure of the cerebellum.

PART III.

CEREBRO-SPINAL NERVES.

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CEREBRO-SPINAL NERVES.

General Remarks.

We shall be brief in the following general observations, which are intended as introductory to the origin, course, and distribution of the cerebral and spinal nerves in detail.

All the nerves arising from the brain and spinal cord are in pairs, which are always symmetrical in their origin, and nearly uniformly so in their course and distribution.

Their most common form is cylindrical; but the olfactory and commencement of the sciatic nerves present instances of exceptions to this rule.

With but few exceptions, their tendency to their destination is direct.

As with arteries, the united diameters of the branches of a nerve considerably exceeds the diameter of the trunk.

Nerves terminate by distribution or anastomoses; the latter may occur either, 1. by an interlacement of the separate filaments of the same nerve; 2. by communication between different nerves; 3. by an interchange of filaments between nerves of opposite sides of the body; 4. by communication with the sympathetic system.

These different species of anastomosis give rise, in various parts of the body, to what are called "plexus." This term signifies properly a network or interlacement of nervous branches or filaments: were it, however, restricted to this definition, the sciatic plexus should be excluded; but in this instance, juxtaposition of the different nervous trunks, without interlacement of filaments, is deemed sufficient to entitle it to the name of plexus[1].

As to structure, the cerebro-spinal nerves seem to consist of medullary matter, similar to that of the brain, deposited in a number of tubes of cellular membrane; and these fibrils are connected by a fine cellular tissue into bundles or fasces, which are contained in a neurilema that is continuous with the pia-matral covering of the brain and cord. This disposition is not, however, invariable.

[1] The following observation of Professor Panizza occurs in a paper of his on the functions of nerves, &c. "The utility of the nervous plexuses appears to be, that by the intermixture which they produce of the filaments of different roots having a common function, they establish among them, so to speak, such concentric force, that each is adequate to preserve the integrity of the same function, when, by means of any lesion, the continuity of the other filaments is interrupted." (Edinb. Med. and Surg. Journal, January 1836, p. 89.)

The fibrils of nerves, when placed under the microscope, appear convoluted: this, no doubt, allows of the nerves accommodating themselves to the motions of the body, without stretching or injury under ordinary circumstances.

Nerves are freely supplied with blood from branches of considerable size; and absorbents have been traced in their large trunks.

In their origins, the cerebro-spinal nerves seldom vary. According to Mr. Swan, the sixth nerve is most subject to deviation: the origin of the spinal accessory is variously given by authors; and Soemmerring notices the varieties of origin that the fourth nerve presents, which are probably more frequent than that of any other[2].

As to the distribution of the cerebro-spinal nerves, we find, as in other structures, and in the various materials that compose the frame, that deviations not infrequently occur, where they are of no real importance and do not interfere with the functions of the organ supplied[3].

[2] For further particulars, see the different nerves.

[3] For the arrangement of some of the preceding observations, the author is indebted to Cloquet's Anatomy.

SECTION I.

CEREBRAL NERVES[1].

THESE consist of nine pairs, which are numerically called according to the position of their origin at the brain, from before backwards; and according to the different foramina they traverse in their exit from the skull; an arrangement that gives rise to the unscientific classification of various nerves together, which possess totally different functions, and which are distributed to widely different organs[2].

These nerves present but few varieties in their origins; and in their distribution, those most subject to deviation are the facial, pneumogastric, and lingual; whilst, as Mr. Swan remarks, "the fifth and nerves of the orbit are generally constant, and the nerves of the senses never vary[3]."

The difference of structure in some of the

[1] Though very dilute nitric acid has been recommended as the best fluid in which to immerse the brain and cord in order to prepare them for a dissection of their structure, yet the student is advised to place in alcohol the parts of the brain he wishes to prepare for tracing the roots of the nerves, till they are sufficiently hardened to facilitate dissection.

[2] Preferring the minor evil, I have selected this arrangement as that most usually adopted by modern works and employed by teachers, and therefore most familiar to the student.

[3] Swan's Demonstrations of the Nerves, p. 31.

nerves from that of the majority will be noticed, together with the known causes for such variations, under the head of each individual nerve.

In describing each cerebral nerve, the following points will present themselves for notice, and will be treated of in the order laid down: origin, course, connexions, form, structure within the skull, exit from the skull, course, communications, distribution. At the conclusion of each description, a summary will be given, including the *function* of the nerve, a notice of its different *communications*, and any physiological or practical *remarks* which may be deemed of sufficient importance to be deserving of observation; and lastly, any deviation from symmetry or other *peculiarity* that the pair of nerves under consideration may present[4].

OLFACTORY NERVES. *First pair.*

Each nerve is connected by three *roots* to the posterior margin of the anterior lobe of the cerebrum; the two lateral medullary, and the central cineritious. The *external* root is brought into view by dividing the arachnoid membrane crossing the interval between the anterior and middle cerebral lobes, and raising the middle artery of the cerebrum: it is a long, narrow, white band, Origin.

The object of these preliminary remarks is, to enable the student to refer with facility to the explanation of any of these points individually.

taking its origin from the outer part of the corpus striatum, and directing itself forwards and inwards along the fissure of Sylvius. The *internal* root is shorter but broader, and may be traced to the fore and under part of the corpus callosum. To expose the *central* root which is superior to the others, the nerve must be raised and thrown back; it arises from the posterior margin of the anterior cerebral lobe, and occupies at its origin the angular interval between the lateral roots; it is therefore conical in form, presenting its apex downwards and forwards, and terminating in a band, the cineritious fibres of which may be traced for some few lines along the upper surface of the trunk. At the point of union of the roots, the nerve presents a triangular bulging, but almost immediately contracts, and assuming a prismatic form, passes forwards along the under surface of the anterior cerebral lobe: in this course it is lodged in a triangular sulcus, and rests on the upper surface of the body of the sphenoid bone. The two nerves, converging as they approach the ethmoid bone, at last rest on its cribriform plate, and are only separated by the crista galli; and each, having gradually lost its prismatic form, here presents an oval bulbous expansion principally consisting of grey matter, *the olfactory ganglion*, from the under surface of which the branches pass to their destination.

Course.

Ganglion.

The *form* of the nerve has been already noticed;

in *structure* and consistence it resembles the general cerebral mass, being soft and pulpy, and unprovided with a neurilema.

The *branches*, of which two sets may be distinguished, become firm immediately after their origin, and descend, for the most part singly, through the ethmoid foramina, each receiving an investment of dura mater which is continued into the pituitary membrane: the *external* set are distributed to that portion of the Schneiderian membrane which covers the turbinated bones; whilst the *internal* set are lost on the membrane of the septum nasi. If the membrane be carefully torn from the bones, these nerves will many of them remain adherent to the periosteum of the latter, on which they may be seen ramifying in various directions and anastomosing with each other, most probably terminating in the villosities of the pituitary membrane. Distribution.

Function. The olfactory nerves are the seat of the sense of smell[1]. Function.

They *communicate* with no other nerves, except perhaps the spheno-palatine filaments[2].

[1] This has been denied by Magendie, who has published a series of experiments to prove that the sense of smell resides in the branches of the fifth. This opinion has received ample refutation; though there can be no doubt that the above-mentioned nerve is essential to the proper performance of the function.

[2] Swan states, "That at the posterior angle of the superior turbinated bone, filaments of the olfactory form a communica-

Peculiarities. The chief *peculiarities* of these nerves are their prismatic form, their soft consistence and partly cineritious structure, their being covered only inferiorly by arachnoid membrane instead of receiving a complete investment, and their multiplied division before leaving the skull. Sometimes the nerve of one side is larger than that of the opposite. The derived branches differ much in different subjects[1].

OPTIC NERVES. *Second pair.*

Origin. These nerves take their origin from the tubercula quadrigemina. Each *commences* by two medullary bands; one from the corresponding nates which joins the corpus geniculatum externum, and the other from the testis, which may be

tion with a branch from the spheno-palatine ganglion;" whilst Cloquet remarks, as one of the peculiarities of these nerves, that their filaments do not anastomose with those of any other nerve. (Swan's Nerves, p. 33.)

[1] Gall and Spurzheim describe a canal as existing in these nerves, which communicates with the ventricles; but Scarpa, Cloquet and others have failed to discover it.

The most elevated part of the nostrils is the true seat of the sense of smell; and, as Richerand observes, "it seems probable that the olfactory nerves do not extend into the sinuses, and that these improve the sense of smell merely by retaining for a longer space of time a considerable mass of air loaded with odoriferous particles." (Copland's Richerand, p. 301.) Cases occasionally occur (one of which is known to myself) where the sense of smell is totally wanting, but in which strong or disagreeable odours are rendered obnoxious through the medium of a more delicate sense of taste.

traced to the corpus geniculatum internum, where it apparently ceases. The different fibres collected from these sources form a flat white band, the *tractus opticus*, which takes its course downwards, forwards, and inwards, winding round the outer margin of the crus cerebri. This band then becomes contracted, and gradually assumes a cylindrical form; and as the two nerves converge, they approach the tuber cinereum, from which they receive some fibres, and then meet on the olivary process anterior to the sella turcica: this union is named the *optic commissure*. The nerves then separate, and diverging, pass forwards and outwards to the optic foramina in the sphenoid bone. Course. Commissure.

As far as the commissure, the optic nerves are only covered inferiorly by pia mater and arachnoid; but from the commissure forwards they receive a complete investment from these membranes. The tractus, in passing round the crura cerebri, are approximated to the fourth nerves and posterior cerebral arteries. The commissure is situated before the pituitary body and floor of the third ventricle: the diverging portion of each nerve passes internal to the carotid artery, which latter separates the former from the other orbitar nerves. Connexions.

Arrived at the foramina, by which they leave the skull, the optic nerves receive a strong investing neurilema of dura mater, whilst the arachnoid covering them is reflected on to this membrane. The foramina being traversed, they become sensibly diminished in size, and direct themselves forwards and a little inwards; their direction being thus altered, a slight curve is formed, the convexity of which is outwards: posteriorly, and rather inferior and internal to the centre of the globe, they traverse the sclerotic and choroid membranes to terminate as will be presently noticed.

In the orbit.

Immediately on entering the orbit, each nerve becomes surrounded by the origins of the recti muscles; further forward it is involved in cellular tissue containing a considerable quantity of adipose matter: in this the lenticular ganglion with its ciliary branches will be found imbedded, the former to the outer side of the optic nerve, the latter surrounding it.

The ophthalmic artery also enters the orbit by the optic foramen; it is at first inferior to the nerve, but soon twining to its outer side, mounts over and gets internal to it: its ciliary branches surround, and its centralis retinæ penetrates, the nerve.

Retina.

The *retina*[1], consisting of three membranous layers, lines the choroid and surrounds the vitreous humour, extending from the optic nerve to within a line and a half of the margin of the lens,

[1] The dissection of the retina should be performed under water.

without however being adherent to either of these structures. The proper nervous layer derived from the optic nerve is placed between the other two layers which compose this membrane; the vascular being anterior, and the serous posterior or external to it[2].

When the humours are removed, and the concavity of the retina examined, the arteries of this membrane are observed radiating from the trunk, which has the appearance of a single dark spot in the centre of the optic nerve; this appearance is called *porus opticus*. About two lines external to the optic nerve, on the retina and directly in the axis of vision, the *punctum aureum* of Soemmerring is observed: it is a yellow spot, about a line in diameter, and usually surrounded by some folds of the membrane: its use and cause of existence are unknown.

Porus.

Punctum.

The retina is naturally transparent; its opake appearance on dissection being the result of a change after death.

Function. The optic nerves are the seat of the sense of vision.

Function, &c.

They *communicate* with no other nerves[3].

[2] It is probable that this serous layer is a reflected layer and of use in protecting the nervous tissue from the pigmentum nigrum. It is very difficult of demonstration.

[3] Arnold delineates two small filaments running up from Meckel's ganglion to join the optic nerve just as it enters the orbit. (*Kopftheil des Vegetativen Nervensystems*, fig. 2.)

With respect to their connexion at the optic commissure, it is yet undecided by physiologists whether the nervous fibres decussate completely and pass each to the opposite organ, or whether there is a simple mingling or identification of the structure of both. Cloquet seems inclined to favour the latter opinion, though, as this anatomist remarks, comparative anatomy and pathology seem to furnish as many facts for one side of the question as the other[1].

Peculiarities.

The chief *peculiarities* of these nerves are, 1. that their structure, consisting of firm white matter, is without the distinct fibrous appearance which most other nerves present on a superficial view; 2. the union of the two to form the commissure; 3. their extent within the skull being greater than that after their exit.

Their external neurilema, which is derived from the dura mater, is continuous with the sclerotic tunic of the eye; whilst they also pos-

[1] Thus the optic nerve of birds is at first single, and subsequently divides into right and left: on the contrary, these nerves in fishes distinctly decussate. Mr. Flood quotes a case in which Vesalius dissected a boy in whom the optic nerves arose and terminated on the same side, being perfectly distinct in their course: in this case sight was perfect during life. (Nervous System, p. 81.) Pathology does not assist in the decision of the question, as a disease of one optic nerve sometimes affects the eye of the same side, sometimes the opposite. (See also Bell's Anatomy, vol. ii. p. 470.) Burns narrates a case in favour of the opinion that they do not decussate. (Surgical Anatomy of Head and Neck, p. 380.)

sess a close investing neurilema, forming canals, in which the medullary structure is deposited.

Remarks. The optic nerve will admit of considerable tension without lesion, as evidenced in cases of dislocation of the globe[2]. Traumatic amaurosis may be produced by direct laceration or piercing of the retina, by tearing from indirect injury, as pressure, or by laceration or stretching of the other nerves of the eye, particularly the frontal branch of the first division of the fifth[3]. Remarks.

MOTORES OCULORUM. *Third pair.*[4]

Each nerve arises from the inner margin of the crus cerebri near its junction to the pons Varolii; Common oculo-muscular.

[2] A case of this kind occurred during my apprenticeship at St. Thomas's. The globe was dislocated by force applied to the outer canthus (the corner of a board struck the eye), and it rested on the margin of the orbit: it was returned by gentle pressure with a moist dossil of lint. There was subsequently some inflammation of the tunics, but sight was unimpaired. This, I am told, is not uncommon in America.

[3] For various information on the subject of amaurosis, the reader is referred to the excellent article in Cooper's Surgical Dictionary. With respect to the last-mentioned mode of producing amaurosis, a high authority on these points states that he believes such consequence of injury to the orbitar nerves to be usually the result of simultaneous mischief to the cerebrum, rather than sympathetic disorganization.

[4] It was originally intended to have given all the nerves of the orbit together; but on consideration it was thought that instead of simplifying, this plan, by throwing nerves out of their regular succession, would tend to confuse the subject. The student is therefore requested, in his dissection of the orbit, to

some of its filaments may be traced into the dark cineritious structure of the crus, and a few to the locus perforatus. It immediately passes between the posterior cerebral and superior cerebellar arteries; after which, receiving its neurilema and being surrounded by arachnoid membrane, it becomes firmer, and directs itself forwards and outwards to the cavernous sinus, resting in its course upon the attachment of the tentorium to the posterior clinoid process of the sphenoid bone. It loses its arachnoid covering on entering the sinus, and traverses a fibrous canal in the outer wall of this cavity, lying above the other orbitar nerves. Just previous to passing the sphenoidal fissure, this nerve divides, and the two branches enter the orbit and arrive at their destination in the following manner:—they both pass between the heads of the external rectus muscle, in conjunction with the nasal branch of the ophthalmic and the sixth nerves; but, subsequently, both nasal and lachrymal branches of the fifth are interposed between the two divisions of the third.

Course.

Branches.

Superior branch. This, which is about half the size of the inferior, passes forwards and inwards above the optic and nasal nerves, and

pursue the following order:—after the third and fourth have been studied, let him trace the fifth as far as the termination of the ophthalmic division; and then turn on to the description of the sixth, at the end of which he will find appended a summary view of the dissection of the cavernous sinus and relative position of the parts contained.

thus gaining the ocular surface of the rectus superior muscle, supplies it and also sends filaments along its inner margin, and through it to the levator palpebræ.

The *inferior branch* appears as the continuation of the trunk. It lies external and inferior to the optic nerve, and runs for a short distance nearly parallel with, but a little inferior to, the lachrymal branch of the ophthalmic, which latter soon leaves it to pass upwards and outwards. It divides into *three* filaments: 1. the internal crosses beneath the optic nerve, and terminates in the internal rectus; 2. the middle is at once distributed to the inferior rectus; 3. the external first detaches a short filament, which mounts up on the outer side of the optic nerve, to join the posterior part of the ophthalmic ganglion; it then runs forwards parallel to and between the internal and inferior rectus, and subsequently between the latter and the globe of the eye, to terminate in the inferior oblique muscle. These filaments, as well as those of the superior branch of this nerve, penetrate the *ocular* surface of the muscles they supply. Inferior branch.

This is the common motor nerve of the eye, distributed to all the muscles except the superior oblique and external rectus. Remarks.

It *communicates* with the lenticular ganglion, and is thus connected to the sympathetic system.

Its *structure* is firm, and in *size* it is intermediate between the optic and pathetic nerves.

Its origin, course, and distribution rarely present any variety.

PATHETIC OR TROCHLEARES. *Fourth pair.*

Pathetic. Each nerve arises by three or four filaments, usually from the testes near to the valve of Vieussens[1], and takes a course forwards, outwards, and downwards, winding round the crus cerebri; and then emerging from between the cerebrum and cerebellum, follows the concave margin of the tentorium: it pierces the dura mater at a point a little external to the third nerve, and runs in a canal inferior to it and above the ophthalmic, along the outer wall of the cavernous sinus. Just before arriving at the sphenoidal fissure, the fourth nerve mounts above the third, being still on its outer side; and perforating the dura mater thus enters the orbit the highest up of all these

Course. nerves. Its subsequent course is first forwards and then inwards towards the superior oblique muscle, lying beneath the orbitar periosteum and

[1] This nerve differs in the number of fibres by which it arises, and, more than any of the other cerebral nerves, in its exact point of origin. This is given variously by authors, from the testis, nates, processus ad cerebellum, valve of Vieussens: I believe that given in the text is the most common. It is Sir Charles Bell's opinion that it comes from the upper part of the spinal marrow, and is connected to the respiratory track described by him.

above the levator palpebræ and oculi muscles; and being at first parallel to the frontal nerve, but afterwards leaving it to pass inwards. It enters, about its centre, the orbitar surface of the obliquus superior, in which it terminates.

This is the motor nerve of the superior oblique muscle of the eye. In Sir Charles Bell's opinion the connexion of its origin to his respiratory track accounts for the sympathetic motions of the eye-ball in combination with the other parts moved in the excited state of respiration. The same *pathological* evidence entitles it to be classed among the excito-motory nerves. Remarks.

It forms no communications. It is unprovided with neurilema, and therefore soft in structure. It is the smallest of the cerebral nerves. Its *origin*, as noticed above, is variable; but its *course* and *destination* never vary.

TRIGEMINI. *Fifth pair.*

Each nerve is found to consist of two portions at its origin, an anterior or smaller, and posterior or larger division. On examining the course of the posterior portion, its fibres may be traced back through the pons to the upper part of the spinal cord, where they are found arising between the corpora olivaria and restiformia: the smaller portion appears to commence in the pons, and by filaments derived from the crus cerebri. The two divisions become approximated, and, pass- Trigeminal.

ing upwards, emerge together from the outer and under part of the pons at its junction with the crus cerebelli. A flattened cord is thus formed, consisting of nearly one hundred filaments which are parallel, distinct, and firm; these conditions result from each fascicle being supplied by a proper sheath or neurilema immediately on separating from the brain[1]. The two divisions or bundles now proceed outwards towards the petrous portion of the temporal bone, receiving an investment of arachnoid membrane, which is subsequently reflected as the nerve enters a canal in the dura mater. Each division is so far distinct that cellular tissue is interposed between them, and not infrequently a small artery runs in the interval: they differ in the following respects. The posterior portion, which is also external, is by far the larger, and more firm in its structure; it expands and becomes flatter as it crosses the depression in the upper border of the petrous

Course.

[1] "On examining," says Cloquet, "all these small nervous filaments with great care, it is seen that those which occupy the centre of the cord receive the neurilema later than those which are situated at the circumference. There results from this that they must break at unequal distances, and this is the reason why, on detaching the trunk of the trifacial nerve from the place where it becomes free, there occurs on the surface of the brain, at the very point which it occupied, a sort of whitish mammilla, which seemed to be concealed in the interior of the nerve, but which is nothing else than the solution of continuity of the filaments which compose it, and not, as Bichat thinks, a particular tubercle."—*Knox's Cloquet*, p. 454.

bone, immediately after which its fibres assume a plexiform arrangement, and terminate in a grey gangliform bulging, which is rounded externally and concave behind, but compressed from above to below: the dura mater adheres closely to its surface, and it rests on the temporal bone immediately before the petrous portion. In structure, the Casserian ganglion—for it is so named—appears to be an intricate plexiform arrangement of nervous fibrils which it is impossible to unravel. From its anterior convex margin three branches are given off: 1. Ophthalmic; 2. Superior maxillary; 3. Inferior maxillary. Casserian ganglion.

That division of the nerve which is anterior and internal, is softer in structure and whiter in colour: it consists of about six filaments, which continue their parallel course beneath and separate from the ganglion of the large division: it subsequently joins the inferior maxillary branch before that nerve leaves the skull[2]. Motor division.

OPHTHALMIC NERVE. *First division of Fifth.*

This is the smallest and highest of the three divisions of the fifth nerve, and continues nearly in the direction of the original trunk, viz. forwards Ophthalmic.

[2] These divisions are described as having no communication within the skull: I have, however, constantly found one or two very delicate filaments running across from the ganglion to the motor portion. Moreover, with the aid of a lens, some of the fibres may be traced through from the cerebral to the opposite side of the ganglion.

Course. and outwards. From its point of separation from the ganglion to the lacerated foramen of the orbit, this nerve is found traversing the cavernous sinus, along the outer wall of which it lies, under cover of the dura mater, and surrounded by a compact layer of cellular tissue. As it advances, it gradually loses the plexiform character of the ganglion from which it was derived, and receives one or two filaments which ascend from the superior cervical ganglion along the internal carotid artery. Its position relative to the other orbitar nerves in the sinus is, below the third and fourth, and above the sixth. Just before entering the orbit, the ophthalmic nerve divides into three branches: 1. frontal; 2. lachrymal; 3. nasal.

Frontal branch. *Frontal nerve.* This is the largest and highest of the three branches. Immediately after it has pierced the dura mater forming the anterior wall of the sinus, it is found taking its course forwards and outwards between the periosteum and superior rectus muscle, and then above the levator palpebræ, upon which it divides into two branches; of these the outer is almost always the larger. Internal. The *internal frontal* or *supra-trochleator* nerve inclines inwards towards the trochlea of the superior oblique muscle, and after giving off filaments which communicate with the terminating twigs of the lachrymal and nasal nerves, and a delicate one which enters the frontal sinus, it emerges, above the oblique tendon, on the forehead, and is distributed to the cranial surface of the occipito-frontalis and corrugator supercilii muscles, and lastly to the scalp. The *external frontal* or *supra-orbitar* nerve continues forwards in the course of the trunk to the supra-orbitar foramen. Previous to emerging, this branch usually divides into several filaments; of these, some communicate very soon with the internal frontal branch and filaments of the facial; the rest pass upwards and backwards, and divide into twigs, which are lost in the corrugator supercilii and occipito-frontalis; and others which pierce the latter muscle, and extending even over the vertex, terminate in the scalp, where they communicate with the facial and posterior branch of the second cervical nerve[1]. External.

Lachrymal nerve. This, which is smaller than the other two branches of the ophthalmic, traverses the lacerated foramen below them and nearly on a level with the inferior division of the third nerve, and piercing the dura mater, takes its course forwards and outwards between the orbitar periosteum and external rectus muscle, to the lachrymal gland. It is accompanied by the lachrymal branch of the ophthalmic artery, and before arriving at the gland, sends a *com-* Lachrymal branch.

[1] In the horse I have traced filaments of this nerve to the bulbs of the eyelashes and Meibomian glands. This and the other frontal branch are the frequent seats of severe and intermittent neuralgic affections.

municating filament through the spheno-maxillary fissure to join the infra-orbitar nerve; and another, the *malar* twig, which perforates the cheek-bone and joins a branch of the facial. The ocular surface of the gland next receives filaments, and the nerve then terminates by a lash of branches, which are distributed to the upper palpebral conjunctiva and skin.

Nasal branch. The *nasal nerve* is intermediate in size between the other two branches of the ophthalmic. It traverses the lacerated foramen between the two heads of the external rectus muscle, and in company with the third and sixth nerves, being parallel but internal to the former, and superior to the latter: it then directs itself forwards and inwards, running along the optic nerve, and lying first beneath the external rectus, and then below the superior oblique muscle, where it divides into an internal and external branch. Previous to this division, its filament of *communication* to the ophthalmic ganglion is separated, and is seen lying along the outer side of the optic nerve; subsequently, two or three *ciliary* filaments are given off, which join those from the ganglion[1].

Division. Of the terminating filaments, the internal or *proper nasal* nerve enters the anterior of the two internal orbitar foramina, and taking a course

[1] See *Ophthalmic ganglion.* Cloquet says that the nasal nerve receives a separate filament from the sympathetic.

upwards and inwards, enters the skull between the frontal and ethmoid bones (which together form the canal it traverses), and passing inwards to the fore and lateral part of the crista galli, it descends, anterior to the olfactory branches, into the nasal fossa. In its course within the skull, this branch lies in a groove along the anterior margin of the ethmoid bone, and is covered by dura mater. Within the nose it is found dividing into filaments, which are distributed as follows: two or three descend along the nasal bone and cartilage, and are distributed to the lining membrane and skin of the nostril; others are given to the pituitary membrane of the nasal chambers. The external or *infra-trochleator* branch continues its course beneath the superior oblique muscle, and arriving at its trochlea, communicates with the supra-trochleator branch of the frontal; then quitting the orbit, its terminating filaments are given to the eyelids and external lachrymal apparatus.

Communications. The ophthalmic nerve receives, before its division, a filament or two from the superior cervical ganglion of the sympathetic. It communicates by the supra-orbitar division of its frontal branch, with the facial, and posterior trunk of the second cervical nerve: by filaments from its lachrymal branch, with the facial, and infra-orbitar division of the superior maxillary nerves: by its nasal branch, with the ophthalmic

Communications.

ganglion: these different branches also communicate with one another[1].

SUPERIOR MAXILLARY NERVE. *Second division of Fifth.*

Superior maxillary.

This, which is named from its destination, superior maxillary nerve, is intermediate in size between the first and third divisions of the fifth. It takes its course from the middle of the ganglion forwards and outwards to the foramen rotundum, which it traverses to gain the spheno-maxillary fossa: the continuation of the nerve then enters the infra-orbitar canal, along which it runs, making its exit by the foramen of the same name on the cheek; and here it spreads out into its terminating filaments.

Whilst within the skull, the fibres of this nerve still retain somewhat of the plexiform arrangement presented by the ganglion: this, however, together with the cineritious character, is gradually lost as it recedes from the ganglion; and at its exit, the component fibrils are bound into a cylindrical form by a closely investing neuri-

[1] Arnold describes two or three filaments, which he names "the recurrent branches of the first division of the fifth." He delineates them as taking their course backwards in the structure of the dura mater of the base of the skull, in which membrane they are lost. He states that they can only be satisfactorily seen by dissection in the head of a fœtus from five or six to seven months old. (*Kopftheil des Vegetativen Nervensystems*, fig. vi.)

lema. The commencement of this nerve lies between the two other branches of the fifth: its course from its origin to its termination on the cheek is, as nearly as may be, horizontal. Filaments are given off from it in the three divisions of its course: 1. in the pterygo-maxillary fossa; 2. in the infra-orbitar canal; 3. on the cheek. Course.

Branches: 1. *given off in the pterygo-maxillary fossa.* The first is the orbitar branch; this ascends with an inclination forwards and outwards through the pterygo-maxillary fissure into the orbit, on the outer part of the floor of which it divides into a *malar* and *temporal* twig: the former, after communicating with the lachrymal nerve, perforates the malar bone, and is distributed to the orbicularis palpebrarum and neighbouring skin, communicating with the facial nerve: the temporal filament pierces the malar bone higher up, near to or at its junction with the external angular process of the os frontis; arrived at the temporal fossa, it communicates with the temporal filaments of the inferior maxillary nerve, and then piercing the temporal muscle and its aponeurosis, becomes subcutaneous, and is distributed to the neighbouring integument, where some of its twigs join others from the facial. Branches. Malar, &c.

It is in the pterygo-maxillary fossa, and usually immediately after the origin of the orbitar branch, that one or two short filaments are passing between the trunk of this nerve and Meckel's ganglion; Communicating.

their course is nearly vertical[1]. Next, and directly afterwards are given off the *posterior superior dental* nerves; they wind round the tuberosity of the superior maxilla, and entering the two or three posterior dental foramina, run along the canals which lead from them through the diploe of the bone, and thus reach the roots of the multicuspid or molar teeth, which they supply. Other small filaments from the same source accompany corresponding branches from the internal maxillary artery, and are distributed to the gums and neighbouring periosteum, and interior of the antrum; some are lost in the maxillary attachments of the buccinator and internal pterygoid muscles.

Posterior dental.

Anterior dental.

2. Whilst in the *infra-orbitar canal*, the *anterior superior dental* nerve is given off. This descends in company with the corresponding artery through the anterior dental canal, which leads downwards from the infra-orbitar, along the anterior wall of the antrum: a filament is first sent back into this sinus, and then the subdivision of

[1] By some, the spheno-palatine or Meckel's ganglion is considered as a portion of the sympathetic; by others, as a ganglion of the fifth. In the arrangement of this work, it will be found described amongst the sympathetic ganglia; but I by no means wish it to be inferred that I believe it necessarily a part of this system. There is much respecting the physiology of the fifth pair that is doubtful and but ill understood; and as it is a ganglionic nerve, it is far from improbable that Meckel's ganglion, in common with some others, may be strictly independent of the sympathetic or internal ganglionic nerves.

filaments takes place by which all the remaining upper teeth, viz. incisors, canine, and bicuspid, are supplied. A communication may usually be traced between the anterior and posterior dental filaments in the antrum.

3. The continuation of the nerve, which is usually called infra-orbitar whilst traversing that canal, now emerges from the foramen of the same name, and the previously separated filaments immediately spread out in a radiating manner on the cheek, and are called according to their destination: 1. malar; 2. nasal; 3. palpebral; 4. labial. They supply relatively: 1. the muscles and skin of the angles of the mouth; 2. the muscles and skin of the nose; 3. the orbicular muscle of the eye, the external lachrymal apparatus, and neighbouring skin; 4. to the muscles, skin, and mucous glands of the upper lip, and to the gums. These anastomose with the other nerves on the face[2]. Infra-orbitar.

Communications. One or two connecting filaments pass between the superior maxillary nerve and the spheno-palatine ganglion, in the pterygo-maxillary fossa. This nerve also communicates by its orbitar branch with the lachrymal branch of the ophthalmic, the facial, and the temporal twigs of the inferior maxillary nerve: also by its Communications.

[2] It is probable that the distribution of these filaments to muscular fibre is more particularly connected with the respiratory division of the excito-motory system.

terminating infra-orbitar filaments, with the facial nerve, and the other divisions of the fifth. Its different filaments communicate with one another.

INFERIOR MAXILLARY NERVE. *Third division of Fifth.*

Inferior maxillary. This is the largest of the three divisions, but the shortest within the skull; for, passing outwards and forwards, it soon reaches the foramen ovale by which it makes its exit. The principal portion of this division is, like the first and second, plexiform; a character which it also gradually loses as it recedes from the ganglion. It is accompanied by the non-ganglionic portion already described, which lies beneath it and cannot be seen till the plexiform division is raised. Course, &c. Passing now nearly vertically into the zygomatic fossa, we find these two portions united and bound together in one neurilema, the smaller or non-ganglionic part first becoming anterior. Immediately on quitting the foramen ovale, this nerve is found lying between the external pterygoid muscle and sphenoid bone, sometimes, not always, in contact with the tensor palati muscle. It soon divides into two portions, an anterior and posterior: the former, which is also external, is the original white bundle, and is distributed to the muscles of mastication; the latter or ganglionic portion is the sensitive nerve of the tongue, teeth, ear, and part of the face[1].

Branches. 1. *Muscular division.* The muscular or motor division of this nerve consists of filaments supplying the muscles of mastication, viz. the temporal, masseter, buccinator, pterygoid; and they are named according to their destination. Branches.

a. Temporal filaments. Usually two in number; they take their course forwards and upwards across the external pterygoid muscle into the temporal fossa: the anterior of these branches is at once distributed to the temporal muscle; but the posterior mounts behind the condyle of the lower jaw; and after also supplying the same muscle, terminates by sending superficial filaments through the temporal aponeurosis to communicate with the facial nerve. Temporal.

b. Masseteric. This filament also crosses the pterygoideus externus in its course backwards: it then passes between the last-named muscle and the insertion of the temporal; and opposite the interval between the condyle and coronoid process of the jaw, it enters the masseter, in the struc- Masseteric.

[1] In order to expose the branches of the inferior maxillary nerve *in situ*, the student is recommended to saw away the coronoid process, leaving the angle of the jaw uninjured. It will be necessary afterwards to make a section through the symphysis of the chin in order to trace the dental and lingual nerves to their termination. Certain filaments are unavoidably destroyed by these sections; but they must be seen on the opposite side.

ture of which it terminates. This filament usually supplies the joint.

Buccal. *c.* The *Buccal* is not always a separate filament; it directs itself forwards and downwards from between the pterygoid muscles: as it proceeds, it lies between the internal pterygoid muscle and ramus of the jaw; and immediately after crossing the coronoid process, gains the buccinator muscle, where it divides into filaments which may be traced as far as the angle of the mouth. The temporal and external pterygoid muscles receive filaments from this branch, as well as the buccinator and muscles about the commissure of the lips: the terminating filaments communicate with the facial and infra-orbitar nerves. There are usually two or three separate fine filaments, *d.* the *Pterygoid,* which pass to the internal muscle of that name.

Pterygoid.

2. *Sensitive division.* We now proceed to trace the distribution of that portion of the inferior maxillary nerve which is derived from the ganglion, viz. the larger or sensitive division; this comprises three branches : temporo-auricular, inferior dental, lingual.

Temporo-auricular. *a.* *Temporo-auricular* branch, passes backwards behind the neck of the lower jaw, and ascends between the condyle and external auditory meatus: after communicating with the facial, we find this nerve giving filaments to the glenoid articulation, auditory canal, concha, &c.; it then emerges from the parotid gland, and in company with the temporal artery mounts over the back part of the zygoma, when it divides into an anterior and posterior branch: these accompany the corresponding arterial branches, and are distributed to the scalp, communicating with the facial and other nervous filaments in this region.

Inferior dental.

b. Inferior dental nerve is the largest of these three divisions. Immediately after their separation it usually communicates with the lingual branch, and takes its course with this division, first between the pterygoid muscles, and then in company with the corresponding artery and vein between the pterygoideus internus and ramus of the jaw, towards the inferior dental foramen. In this latter position it does not lie in immediate contact with the last-named muscle, but is separated from it and the lingual division of the nerve by the membranous expansion of the internal temporo-maxillary ligament as it passes to be attached into the line leading from the aperture of the dental canal.

Branches.

Branches. Just previous to entering the canal in the inferior maxilla, a long filament, the *mylo-hyoidean,* is separated: it passes downwards and forwards in a groove on the inner surface of the ramus of the jaw, in which it is confined by the membranous expansion already alluded to: it next lies on the maxillary surface of the mylo-hyoideus muscle; and passing anterior to the submaxillary gland to which it gives filaments, terminates in the mylo-hyoideus and anterior belly of the digastric muscle.

The inferior dental nerve now enters the canal of that name, together with the corresponding branch of the internal maxillary artery and its accompanying vein. Here it gives off the filaments to the teeth of the lower jaw: a branch is supplied to each multicuspid and bicuspid tooth in succession, and then the principal portion of the nerve escapes by the mental foramen; a small division is continued onwards for the supply of the canine and incisor teeth. That division which is destined for the chin divides immediately after its escape from the mental foramen, and whilst beneath the depressor of the lower lip, into a number of filaments, which pass in a radiating manner to their destination: some are lost in the muscles of the lower lip and buccinator; others pass to the mucous membrane and glands of this region; and lastly, the skin of the under lip and chin receives a large supply. These filaments also communicate with the facial nerve[1].

Mental filaments.

[1] Sir Charles Bell mentions an instance in which there was loss of sensation of one side of the lower lip after extraction of a tooth: the dental nerve had no doubt been torn through. (Bell's Lectures, Med. Gaz., vol. i.) Merely raising a tooth and then returning it to its socket may, by cutting off its nervous supply, prove a cure for toothache; and might be practised where comparative soundness of structure rendered extraction unadvisable.

c. The *Lingual branch* gradually separates from the dental, than which it is somewhat smaller; and is almost immediately joined at an acute angle by the corda tympani, just after that small nerve has escaped from the glenoid fissure of the temporal bone[2]. After their separation, however, these two large divisions of the inferior maxillary nerve continue in company as they pass between the pterygoid muscles. The lingual branch is then found lying between the expanded internal lateral ligament of the lower jaw and the internal pterygoid muscle; and descending obliquely downwards and inwards behind the last molar tooth, it insinuates itself between the upper margin of the submaxillary gland and the mucous membrane of the mouth. Here it becomes expanded and flattened, and joins the Whartonian duct, together with which it passes between the mylo-hyoid and hyo-glossus muscles, and crossing the insertion of the latter, mounts above the sublingual gland to divide into its terminating branches on the outer surface of the genio-hyo-glossus muscle.

Lingual.

Course.

[2] For a description of the corda tympani, the reader is referred to the spheno-palatine ganglion, of which it is a branch. It passes, under the name of *vidian* or *recurrent pterygoid* nerve, through the pterygoid, anterior lacerated, and vidian foramina into the tympanum, which it traverses, joins the facial, and then quitting it, emerges as described in the text: its subsequent destination is to the submaxillary ganglion, to which also the reader is referred.

Branches.

Branches. The first filament which this nerve gives off is to the internal pterygoid muscle ; and soon afterwards, before arriving at the gland, others are separated, which are distributed to the tonsils, and neighbouring mucous membrane of the mouth, gums, side of the tongue, and upper part of the pharynx. It next supplies the two salivary glands, giving filaments to join, in company with the corda tympani, the submaxillary ganglion. It communicates freely with the lingual motor nerve, principally on the outer surface of the hyo-glossus muscle. The terminating filaments, which are the most considerable, pass upwards between the stylo-glossus and lingualis externally, and the genio-hyo-glossus internally, and penetrating the muscular structure, are lost in the mucous membrane and papillæ of the whole surface even to the tip of the tongue.

Communications.

Communications. By the temporal, buccal, and temporo-auricular branches, and mental filaments of the inferior dental, with the facial nerve ;—by the buccal with the infra-orbitar nerve ;—by the lingual branch with the corda tympani and lingual-motor nerve ;—the lingual and dental branches communicate together[1].

Physiology of fifth.

Function. The fifth nerve is, in character and

[1] Mr. Swan describes filaments which pass from the inferior dental branch along the internal maxillary artery, to communicate with filaments of the sympathetic on the internal carotid. (Demonstration of the Nerves, p. 42.)

function, similar to a spinal nerve. It possesses two roots, one of which is simple, the other ganglionic: experiment has proved that division of the latter destroys the sensibility of the face; and that the control over the muscles of mastication is lost when the former is divided[2]. It is, therefore, both a sensitive and motor nerve; and its sensitive division is, moreover, in common with the posterior roots of the spinal nerves, an excitor branch of the excito-motory system. Whether its ganglionic character may imply some further property which it possesses in common with the sympathetic system appears still doubtful, though far from improbable.

The minor portion of the nerve is solely distributed to muscles, and possesses properties common to all muscular nerves; but the distribution of the ganglionic portion is more extended, and of sufficient importance to arrest our attention for a few moments. We find that the ratio of its development is inverse to that of the brain; or in other words, "as the brain becomes more simple, and the intellectual faculties, of which it is the seat, fewer and more imperceptible, the fifth pair of nerves and instinctive faculties are more and more developed[3]." Independent of the *common*

[2] Bell's Anatomy, vol. ii. p. 386.

[3] For convenience the student may consult Parker's Lectures on Comparative Anatomy, published in the Medical Gazette; particularly that in vol. vii. p. 69.

sensation with which the three divisions of this nerve endow the contents of the orbit, nasal membrane, forehead, face, mouth, &c., we find that there are certain branches which are more or less connected with the *specific* sensibility of the eye, nose, and tongue—with the senses of sight, smelling, and taste. The interruption of the functions of different parts of this nerve by accident or for experiment proves these facts[1]. Whether the lingual branch of the third division of the fifth be really the nerve of taste or not[2], there can be

[1] See practical remarks further on; and remarks attached to the olfactory, optic, and glosso-pharyngeal nerves.

[2] The reader is begged at any rate to suspend his judgment upon this matter until he has read an article in the Edinburgh Medical and Surgical Journal for January 1836, entitled "Experimental Researches on the Nerves," by Professor Panizza, and translated from the Italian by David Craigie, M.D., &c. The interesting results of these experiments may excuse my extracting some passages relative to the nerves of taste. The first nerves divided were the hypoglossal (ninth pair), respecting which the following observations occur: "Before dividing the hypoglossal, and while it was held raised on the probe, having pricked it with the point of the scissors, the tongue was agitated every time, and the animal appeared incapable of suffering; an incapacity which it retained during the process of division. Conversely, when the same trials were renewed upon the lingual branch of the fifth pair, the animal gave indications of suffering the most acute pain, without any motion of the tongue appearing. . . . . . The effect which immediately follows division of the two lingual nerves" (of the fifth, upon which the Professor next experimented,) "is, on the contrary, complete extinction of tactile sensibility of the tongue, with remaining motion and taste." This was proved by the dog taking food, and rejecting with "marks of unequivocal dis-

little question that its filaments supply the tongue with that exquisite delicacy of touch to which the endowment of no other part of the body approaches: therefore, if the former position be admitted, its function must be double.

The evidence of the excitability of the fifth and its connexion with the respiratory motions is more particularly treated of in the physiological section: the student may, however, be reminded that the respiratory effort produced by dashing cold water in the face is an excited act; as also is sneezing from the application of stimuli to the nostrils, &c. According to Dr. Marshall Hall, this pair ranks amongst the external nutritive nerves.

Practical remarks. The effects occasionally produced by injury to different parts of the fifth nerve illustrate its intimate connexion with the above-mentioned senses, and their dependence on its soundness for an unimpaired condition of Practical remarks.

gust" portions of meat dipped in a bitter but scentless solution. Lastly, on dividing the glosso-pharyngeal nerves, the Professor remarks: "The dog in which this pair was divided having recovered from the state of depression in which he was immediately after the operation, lapped water, and ate as freely as if he had suffered no injury, and that afterwards mastication and deglutition were performed: . . . . . but he swallowed with readiness the most disgusting and noxious articles. . . . . He moreover still retained the tactile sensibility of the tongue, since scarcely was it touched by a needle when he howled with pain and tried to run off." For further observations on these subjects, the reader is referred to the notes attached to the lingual-motor and glosso-pharyngeal nerves.

their functions. It has been already remarked (see *Optic nerves*) that injury of the ophthalmic division is not infrequently followed by amaurosis, but that this may often be traced to some concomitant cerebral lesion. We have, however, cases on record where blindness has resulted from slight injuries, such as simple puncture of the frontal nerve[1]. Further, by cutting off the influence of the ophthalmic nerve the surface of the eye may be rendered totally insensible, whilst the other functions are not necessarily impaired; the effects are disastrous, in that extraneous matters are allowed to collect unnoticed on the conjunctiva, which is no longer swept, as occasion requires it, by the upper palpebra; nor, for the same reason, is the flow of tears proportioned to the necessity arising from any extra source of irritation requiring this lubrication in addition to that which is ordinarily derived from the conjunctive membrane alone. The terminating branches of the three divisions of this nerve on the face are the frequent seat of that severe neuralgic affection called "tic douloureux." The operation of di-

[1] The reader is referred to works on Ophthalmic Surgery, article "Amaurosis." I remember removing from the supraorbitar ridge, a small cyst which pressed upon the nerve at its exit. Previous to the operation, this individual was short-sighted on the affected side, but regained natural vision afterwards. It is possible that in this case there might have been some pressure on the globe, although I suspected not at the time.

viding these for the cure of this disease has been practised, but with so little success that it is now nearly abandoned. It has been proved that simple section is next to useless; on reunion of the cut extremities, the complaint returns with all its force: and even the abstraction of a portion of the nerve is rarely followed by permanent benefit[2].

ABDUCENTES. *Sixth pair.*

Each nerve arises from the upper extremity of the corpus pyramidale, and issues from the brain at the grooved junction of this body with the pons Varolii. Becoming enveloped by a neurilema and process of arachnoid, it ascends forwards and outwards towards the posterior clinoid process, just before reaching which its serous membrane is reflected, and it pierces the dura mater to enter the cavernous sinus. In this course it is situated between the pons above and the cuneiform process of the occipital bone below; and the basilar artery separates the two nerves. It then traverses the cavernous sinus in close connexion with the external side of the carotid artery, holding a situation inferior to the other orbitar nerves, and having a process of the lining venous membrane

Abducent.

Course.

[2] The result of the experience of some eminent surgeons does not totally agree with this opinion. Neuralgia may be dependent upon distant functional or organic derangement, or it may be a purely local affection, as from injury, &c.,—points requiring consideration previously to undertaking a cure by operation.

folded around it. It is here that this nerve receives two or three communicating filaments which ascend from the superior cervical ganglion of the sympathetic along the carotid artery, thus reaching their destination on the outer side of this vessel in the cavernous sinus[1].

Arrived at the sphenoidal fissure, we find this nerve still inferior and external, but intimately connected to the third and nasal branch of the ophthalmic, and all three together pass into the orbit between the two heads of the external rectus muscle, and immediately above the orifice for the ophthalmic vein. It does not leave the above-named muscle, but is continued along its ocular surface, and divides into two or three bundles of radiating filaments, which are ultimately lost in its substance.

Termination.

Function.

Function. This is the motor nerve of the external rectus or abductor oculi muscle, and is, as well as the fourth, under the control of the excito-motory centre, as evidenced by the spasmodic abduction of the eye during an epileptic attack, &c.

Communications.

It receives *communicating* filaments from the first cervical ganglion of the sympathetic.

[1] See Sympathetic—Superior Cervical Ganglion. It may be remarked that Professor Panizza denies the union of these branches. He states that the sympathetic filaments twine around without actually joining with the sixth nerve. (Edinburgh Medical and Surgical Journal, January 1836, p. 72.)

In *structure* it is firm, and of a *size* intermediate between the third and fourth. It is described variously, as to the point of its origin, by different authors[2].

THE SPHENOIDAL SINUS AND ITS CONTENTS.

The following recapitulation may serve to give the student a comprehensive view of the more intricate part of his dissection of the orbitar nerves, &c. Sphenoidal sinus.

The sphenoidal fissure is closed by that process of dura mater which is continuous with the periosteum of the orbit, and which presents the several apertures for the vessels and nerves passing in and out of the orbit. The dissection of the dura mater in this region presents the following appearances: the walls of the cavernous sinus Walls. having been formed, and an envelope sent off around the middle and inferior divisions of the fifth nerve, we find three canals which are destined for three of the orbitar nerves. These are not distinctly fibrous throughout, but are formed externally by the outer wall of the sinus, and internally and anteriorly are cellular in texture. The superior of these canals is for the third Canals. nerve, the middle for the fourth, and the inferior

[2] The combined action of the lateral recti muscles of each eye to produce the requisite abduction of one organ whilst the other is adducted is curious, in that the influencing nerves are derived from different sources.

for the ophthalmic division of the fifth. A separate aperture admits the sixth nerve into the cavernous sinus; and the anterior wall of this cavity, which is formed by the dura mater closing the sphenoidal fissure, is also pierced by the several nerves close together, and above the aperture of the ophthalmic vein. This sinus also presents other openings, which, however, have nothing to do with the parts under consideration: for further information, the reader may refer to the description of the sinuses.

It has been stated that the sixth nerve perforates the posterior wall of the sinus separately; it will be found immediately inclining downwards and outwards, and not lying, like the others, *in* the wall of the sinus.

Order of nerves.

Whilst traversing the cavernous sinus, the order of the nerves is numerical from the third which is highest, to the sixth which is lowest and most external. Their relative position changes, however, as they pass the sphenoidal fissure; it is thus: highest up, the fourth; then the *frontal* branch of the ophthalmic (fifth); next the superior division of the third; after which the *nasal* and *lachrymal* branches of the ophthalmic (fifth); still lowest down, the sixth[1].

Of these there pass between the two heads of

[1] The nasal and lachrymal branches are nearly on a level as they pass the fissure, the former being usually rather the higher. I have found this a little variable.

the external rectus muscle the whole of the third, the nasal branch of the fifth, and the sixth nerves.

The relation which the nerves bear to the internal carotid artery (which is also within the sinus) is that they are all *external* to it, but none in contact with it, except the sixth. Relation to artery.

From what has been already said, it is clear that none of these bodies, in their passage through the sinus, are actually in contact with its blood. The carotid artery, the sixth nerve, and the communicating filaments of the sympathetic receive an investment from the lining venous membrane; whilst the third, fourth, and ophthalmic division of the fifth are contained in fibro-cellular canals.

FACIAL AND AUDITORY NERVES. *Seventh pair.*

FACIAL NERVE[2], OR PORTIO DURA OF THE SEVENTH PAIR.

The origin of this nerve is from the medulla oblongata at its junction to the pons Varolii. Its fibres arise above those of the glosso-pharyngeal, but from the summit of the same column as the eighth pair, viz. between the corpus olivare and restiforme (the respiratory track of Bell). Facial motor.

At its emergence from the brain the facial is situated immediately anterior to the auditory

[2] This forms by itself the seventh nerve of some authors, a classification, as before observed, less open to objection than that adopted in the text, which however is the more commonly used in our schools.

nerve; and the two are usually connected by a few filaments passing from the latter to the former. The portio dura, which is at first white and soft, soon becomes invested by a neurilema, and as-
Course. sumes a firmer consistence. Its course is forwards, upwards, and outwards, in company with the portio mollis, towards the internal auditory foramen, which they both enter together. In their passage thither, the two nerves are so connected that the facial grooves the auditory, but they are separated by a small artery belonging to the internal ear, and derived from the basilar or superior cerebellar branch. As they enter the auditory canal, the facial is internal of the two. At the bottom of this canal the two nerves part company, the portio mollis to be distributed as will be described anon, and the portio dura to enter the aqueduct of Fallopius[1], which it tra-
Exit. verses, and makes its exit by the stylo-mastoid foramen. Opposite the hiatus Fallopii the facial is joined by the Vidian or recurrent pterygoid nerve[2], which subsequently leaves it to enter the

[1] The aqueduct of Fallopius commences by a fissured orifice at the bottom of the meatus auditorius internus: it first passes upwards and outwards, and presents the hiatus Fallopii, which transmits the Vidian nerve: it then passes directly backwards over the tympanum, and subsequently descends along the inner wall of that cavity to terminate by the stylo-mastoid foramen.

[2] For the description of this nerve turn to "Meckel's ganglion."

tympanum. Whilst in the aqueduct the facial nerve gives a filament to the tensor tympani, and also one to the stapedius muscle. Immediately as it issues from the stylo-mastoid foramen, the three following filaments are derived from it[3]. Branches.

Posterior auricular. This branch first descends, and then winding upwards along the anterior portion of the mastoid process, gains the posterior surface of the concha, and divides into two filaments; the anterior is distributed to the auricular cartilage and small muscles, whilst the posterior divides into twigs, which supply the occipito-frontalis and superior attachment of the mastoid muscles, and neighbouring integuments, anastomosing with filaments from the cervical plexus. Auricular.

Sub-mastoid. This branch almost immediately penetrates the posterior belly of the digastric muscle which it supplies; two filaments then leave the inner surface of the muscle, one ascending to communicate with the glosso-pharyngeal nerve behind the jugular vein, the other descending to join the superior laryngeal nerve. Sub-mastoid.

[3] The inexperienced dissector will prove some difficulty in finding the trunk of the facial nerve at its exit from the stylo-mastoid foramen: he is therefore recommended to select one of its branches on the cheek, and trace it back to the root. If a portion of the mastoid process be carefully chiselled away, it will facilitate the dissection. The depth of the stylo-mastoid foramen is less in the child than the adult, and the dissection consequently easier.

Stylo-hyoid.

Stylo-hyoid. This is principally distributed to the muscle of the same name; but also gives filaments to the other styloid muscles, and communicates with the first cervical ganglion.

Subsequent course.

The trunk of the facial nerve now penetrates into the parotid gland, at first lying deeply, but subsequently, as it passes downwards, approaching the surface: and after a passage of rather better than half an inch, and whilst still deeply imbedded in the parotid, it bifurcates. During this short course, it crosses the external carotid artery immediately previous to its terminating division into temporal and internal maxillary branches: a small portion of the gland is usually interposed between the nerve and vessel.

Plexus.

The two divisions which result from the bifurcation of the nerve above noticed, are named, according to their destination, temporo-facial, and cervico-facial. These divisions communicate freely, and the derived filaments also anastomose so as to form a remarkable interlacement, which is named the parotidean plexus[1]. We will now trace the distribution of each division.

The *Temporo-facial* or superior division is considerably the larger: it directs itself upwards and forwards through the substance of the gland

[1] Or *pes anserinus*, from its supposed resemblance to a goose's foot. To trace this intricate interlacement without destroying branches, it is requisite to use great care in picking out the granules of the gland from the interstices.

towards the condyle of the lower jaw which it crosses, and subdivides into three sets of branches, —temporal, malar, and buccal. 1. The *temporal* are two or three small filaments which ascend forwards over the zygoma, and are distributed to the integuments and muscles of the frontal, temporal, and auricular regions: they communicate with one another, and with the malar and auricular twigs from the same source; also with the three divisions of the fifth by the following branches; supra-orbitar and lachrymal of the ophthalmic, orbitar of superior maxillary, and temporal branches of the inferior maxillary: and likewise with the auricular branch of the cervical plexus. 2. The *malar* branches are also two or three in number, and their direction is towards the malar bone: they spread out into numerous filaments, which are distributed to the neighbouring integument of the cheek, and the levator muscles of the upper lip. They communicate with the other two branches of the temporo-facial division, and with filaments of the ophthalmic nerve, and infra-orbitar branch of the superior maxillary. The *buccal* branches usually consist of three distinct filaments which take a transverse direction: the *superior*, supplying the ala nasi and muscles of the upper lip; the *middle*, a considerable branch, accompanying and usually placed between the transverse facial artery and parotid duct, and distributed, together with the *inferior*, which is

Temporal.

Malar.

Buccal.

smaller, to the commissure of the lips. Besides the communications already pointed out, these filaments anastomose with the infra-orbitar nerve, and the mental and buccal filaments of the inferior maxillary. Many of the twigs of these nerves, and especially the buccal, accompany the facial vessels.

The *Cervico-facial* or inferior division, smaller than the superior, passes downwards and forwards in the substance of the parotid to the posterior part of the angle of the jaw; and after emerging from the gland, and whilst under cover of the platisma, it gives off its branches. These are irregular but usually from four to six in number, and arranged into supra-mental or those above, and infra-mental or those below, the level of the chin.

Supra-mental. The *supra-mental* branches are usually two in number, which take nearly a horizontal course: they pass beneath the platisma across the angle of the lower jaw and masseter muscle, and subsequently traverse some fibres of muscles of the mouth, to which, viz. those of the cheek, upper and lower lip, they are distributed, anastomosing with the temporo-facial division, and the infra-orbitar, buccal, and mental nerves.

Infra-mental. The *infra-mental* or proper cervical branches, from two to four in number, divide into numerous filaments which take a curved descending course over the angle and ramus of the jaw, and between the platisma and fascia; they are distributed to these parts and the cervical integuments, communicating with the last-described and the superficial ascending branches of the cervical plexus.

Communications.

Communications. The facial nerve communicates with the auditory in the skull; with filaments of the cervical plexus, by its auricular, temporal, and infra-mental branches; with the glosso-pharyngeal and superior laryngeal nerves, by its sub-mastoid branch; with the superior cervical ganglion, by its stylo-hyoid branch; with the three divisions of the fifth, by its temporal, malar, buccal, and supra-mental branches. It is also joined in the aqueduct of Fallopius by the Vidian nerve, but it is not supposed that they anastomose[1].

Function.

The *function* of the facial nerve is to preside over the motions of the face, whilst the branches of the fifth, it will be remembered, are the nerves of sensation. Moreover, the experiments of Sir Charles Bell prove that it belongs to the class of respiratory nerves[2]. Indeed, pathology tends to prove this fact; for the necessity of combining the action of the muscles governing the apertures of the mouth and nostrils with the general respiratory system, if not self-evident, is sufficiently evinced by marking the effect when the con-

[1] Mr. Swan, however, gives it as his opinion that their fibres intermix. (Demonstration of the Nerves, p. 42.)

[2] Being, therefore, a *motor* nerve of the excito-motory system.

trolling nervous influence is suspended; the tendency of each inspiration then is to close the apertures and invert their margins[1]. Add to which, the simple motion of the lips to effect articulation implies a complicated and combined act of different parts of the respiratory apparatus[2].

Practical remarks.

Remarks. The deep connexions of the facial nerve at its exit from the skull,—the mode in which it is imbedded in the parotid gland, and its proximity to the external carotid artery,—should all be subjects of careful study to the surgical anatomist. He may learn from these facts to account for paralysis of the face occasioned by glandular or deeply seated tumours; he may see the extra obstacle this nerve presents in that next to impossible operation of removing the parotid gland: again, the excruciating pain attending cynanche parotidea is, at any rate in part,

[1] This may be observed in the dying, but peculiarly so where death is produced by effusion into the base of the skull. I have marked in such cases, after the convulsive distortion of the features has passed away, that the short period during which, at gradually more and more protracted intervals, respiration is continued, the apertures are always inverted. It would seem as if the facial nerve ceased early to respond to the excited impression; or, as might sometimes be the case, became paralysed from more limited pressure than can be supposed to result from general effusion.

[2] The dissections and observations made by Professor Müller of Berlin lead him "to assume that the facial nerve even at its origin is by no means a simple or merely motor nerve." The remarks are too lengthy to extract, but will be found in his *Handbuch der Physiologie des Menschen*, vol. i. p. 644.

explained; for, let it be understood that the fact of its being a motor nerve does not exclude the facial from being sensible: in its free communications with the fifth pair, a sufficient number of fibrils of the latter find their way along the branches of the portio dura to render it highly sensible under pressure or from inflammation. The cause of paralysis of this nerve, attending deafness, is sometimes explained by a free discharge of matter from the ear. This nerve is the seat of the disease named "spasmodic or convulsive tic," characterized by twitching of the muscles of the face, unaccompanied by any affection of the fifth pair[3].

Peculiarities. The order of subdivision of the branches of the facial is subject to considerable variety, though their ultimate distribution is pretty regular: otherwise this nerve presents no remarkable peculiarities. Peculiarities.

AUDITORY NERVE, OR PORTIO MOLLIS OF THE SEVENTH PAIR[4].

The auditory nerve is found to arise in the fore part of the floor of the fourth ventricle, by a slightly elevated transverse band immediately Auditory.

[3] The remarks in the text comprise only a few of the more leading pathological conditions of the facial nerve. The reader may refer for more information to the interesting observations and experiments of Sir Charles Bell, in the second volume of his "System of Anatomy"; and other authors.

[4] The eighth nerve of some authors.

above the restiform body. This origin is usually, but not necessarily[1], connected to the medullary striæ of the calamus scriptorius; and a few fibres derived from the pons Varolii near its junction to the crus cerebelli complete this nerve, which becomes separated from the substance of the brain in a fossa situated at the junction of the pons with the crus cerebelli and corpus resti-

Course, &c. forme. At first pulpy, it soon receives its neurilema and assumes a firmer consistence and more fibrous structure[2], and becomes connected to the facial, to which, as already noticed, it gives some fibres: we remark, moreover, that the portio mollis, which is posterior, is grooved by the portio dura as they run, parallel but separated by a small artery, towards the internal auditory foramen. At the bottom of the internal auditory canal the portio mollis bifurcates, whilst the facial passes on to its destination as already described.

Branches. *Branch to the cochlea.* At the bottom of the internal auditory canal, this divides into a number of fine filaments which enter the cochlea through the foramina in its base; these ramify,

[1] According to Soemmering, Santorini, and others.

[2] Cloquet remarks, "All the filaments which enter into its composition are very delicate, and anastomose with each other, so as to form a very complicated and dense plexus; only at its back part, a whiter and softer cord which is not filamentous may be observed; this portion is distributed to the cochlea." (Knox's Cloquet, p. 468.)

forming an intricate network on the lamina spiralis and modiolus; and are distributed also to the hollow and expanded portion of the latter, the infundibulum[3].

Branch to the vestibule and semicircular canals. This branch is subdivided into three portions which enter the vestibule by several apertures to be seen on its inner surface, and communicating with the internal auditory canal: these filaments are lost in the lining membrane of the vestibule and semicircular canals.

The only *communication* of this nerve is with the facial within the skull. The soft portion of Function. the seventh is the nerve of hearing.

Remarks. This nerve is subject to lesion Remarks. in fractures which extend through the petrous bone; and probably not infrequently so in severe concussion of the brain, where deafness is no uncommon sequence. In its progress through the petrous portion of the temporal bone, the proximity of the internal carotid artery to the parts concerned in the function of hearing may account for the sensible effects which are produced upon this delicate organ by the præternatural or morbid action of the arterial system[4]. It would appear Physiology.

[3] "Seen," as Mr. Swan observes, "with the aid of a magnifying glass, to form a network, which furnishes a beautiful example of the termination of a nerve, as exhibited in a more fibrous expansion than that of the optic in the retina." (Demonstration of the Nerves, p. 45.)

[4] See Harrison's Surgical Anatomy of the Arteries, vol. i. p. 76.

that all which is absolutely required for the production of the impression we call 'sound,' is, that the vibration of the particles of the atmosphere should be conveyed to, and allowed to act upon, the expanded extremity of this nerve; at least we know that injury, even to destruction of the membrane of the tympanum and small bones of the ear, may occur without perfect deafness resulting. The pathology of this complaint is, however, like many other nervous affections, involved in considerable obscurity; but it is not unphilosophical to argue that the auditory nerve is peculiarly and specifically adapted for receiving and conveying to the sensorium the impressions produced by the varied vibrations of the atmosphere, in the same way that the retina acknowledges the agency of a more attenuated medium, by which the impressions we call 'light' and 'colours' are generated and distinguished: the analogy between the organs of 'hearing' and 'sight' is rendered complete by recognising the ossicula, canals, chambers, &c. as holding the same relation to the former as the lens, humours, membranes, &c. do to the latter, viz. as collateral aids necessary to the perfection of the function of the organ to which they relatively appertain. It is not probable that the Eustachian tube is capable by itself of transmitting any distinct sounds; the gaping attitude of an attentive listener being assumed the rather for the purpose of better accommodating the external passage for the collection of sound, an effect which is much aided by depression of the condyle of the jaw. The external apparatus of the eye and ear hold an analogous relation to these several organs, in augmenting or modifying the subsequent impression.

In *consistence* the auditory nerve is firmer than the olfactory, but less so than the optic. In *size* it exceeds the common oculo-muscular. The pair is always symmetrical. Structure, &c.

EIGHTH PAIR OF NERVES[1].

GLOSSO-PHARYNGEAL—PNEUMOGASTRIC—SPINAL-ACCESSORY.

GLOSSO-PHARYNGEAL NERVES. *First division of the Eighth*[2].

These nerves arise the highest of the three divisions of the eighth pair, each commencing by four or five filaments, and sometimes less, from the middle track of the medulla oblongata (*respi-* Origin.

[1] To make a dissection of the eighth and ninth nerves, the student is recommended to saw off about an inch of the angle of the jaw, and to chisel away the mastoid process, if this have not been already done in the previous dissection of the seventh pair. The sterno-cleido-mastoid should be drawn back; and it is well, moreover, to divide and reflect the digastric and stylo-hyoid muscles, together with the external carotid artery; but this should be done so as to replace these parts at pleasure. It will be requisite, at a future stage of the dissection, to make a further section into the posterior lacerated foramen, to expose these nerves at their exit from the skull.

[2] The *ninth* nerve of Arnold and others.

ratory track of Bell), emerging from between the corpus olivare and restiforme, and extending from a short way below the facial to near the pneumogastric. These filaments unite to form a single trunk, which is first placed above the par vagum; and subsequently, as it passes forwards and outwards and enters the posterior lacerated foramen in the base of the cranium, it is placed anterior and rather external to this nerve. In its passage from the skull, the glosso-pharyngeal nerve is invested by itself in a sheath of dura mater.

Branches.

Its first branch after its exit is the tympanitic, which traverses the petrous bone by a canal opening near the stylo-mastoid foramen, and entering the tympanum, communicates with the Vidian nerve. After receiving filaments sent to it from the stylo-hyoid branch of the facial, from the par vagum, and superior cervical ganglion of the sympathetic, we find the trunk of this nerve pursuing an arched course forwards and inwards to its termination, being parallel to, but deeper and on a plane between, the motor and sensitive nerves of the tongue. It is first placed anterior to the internal jugular vein, and then crossing to its inner side, accompanies the stylo-pharyngeus muscle between the external and internal carotid arteries, of which the former is before, the latter behind it. The nerve gradually winding round this muscle, passes from its deep to its superficial surface, and inserting itself between it and the stylo-glossus,

Continued course.

arrives at the base of the tongue where it terminates. It communicates with the pharyngeal plexus, and its ultimate filaments are distributed to the mucous membrane of the base of the tongue, epiglottis, tonsils, and upper part of the pharynx[1]. Distribution.

Communications. With the Vidian in the tympanum; with the stylo-hyoid branch of the facial; by filaments received, with the par vagum and superior cervical ganglion; also with the pharyngeal plexus. It has no apparent communication with the other nerves of the tongue. Communications.

The glosso-pharyngeal has long been considered as the nerve of deglutition; but the recent experiments of a Continental physiologist tend strongly to disprove this opinion, and to establish the fact that it is solely the nerve of 'taste,' and that the act of deglutition is presided over by the lingual-motor or ninth nerve[2]. Function.

[1] Muscular filaments are frequently described. I do not pretend to say whether such actually exist; but I have seen some small twigs creeping along the stylo-pharyngeus muscle, and others apparently passing to the constrictors of the pharynx. I have little doubt that the latter pass to the mucous membrane; and it is very probable the former do likewise. Professor Panizza states that this nerve gives off no muscular filaments.

[2] The following observations relative to the function of the glosso-pharyngeal nerve, I extract from the paper before cited, of Professor Panizza, in the Edin. Med. and Surg. Journal for January 1836. "The dog in which both pairs of hypoglossal and lingual" (ninth and lingual of fifth) "were divided, was absolutely deprived of the motion and the tactile sensibility

This nerve is not likely to be interfered with in any ordinary surgical operation. In origin, course, and distribution, it rarely presents any deviation from the order laid down.

PNEUMOGASTRIC NERVES[1]. *Second division of the Eighth.*

Origin. Each nerve arises from the same track, and immediately below the glosso-pharyngeal: the original fibres combine to form about eight or ten firm fasciculi, which leave the medulla oblongata between the corpus olivare and restiforme, and

of the tongue, and taste was nevertheless unimpaired; because in whatever point the tongue was touched with the coloquintida solution, he uniformly expressed disgust by the specified signs, which were more manifest and enduring if the tongue were touched towards the base...... If, before dividing the glosso-pharyngeal nerve, it be pinched or punctured by the forceps, neither does the animal give sign of uneasiness, nor is the tongue convulsed...... After the division of both nerves of this pair, mastication and deglutition were perfect, and the animal swallowed the most disgusting food, provided it did not smell...... Ascribing in this manner to the glosso-pharyngeal nerve the gustatory faculty, I think that many phenomena of intimate sympathy or consent which take place between the tongue and the stomach, may now be more easily and directly explained than was done by ascribing that faculty to the lingual branch of the fifth pair." In support of opinions opposed to these, the reader is referred more particularly to Magendie's Physiology, and Bell's Nervous System.

[1] Or paria vaga. This pair of nerves is not symmetrical throughout; the same description will, however, suffice for both sides, and the points in which they differ will of course be indicated as we proceed. They form the tenth pair of some authors.

converging, run parallel to each other and beneath the glosso-pharyngeal, to the posterior lacerated foramen in the base of the skull. In making its exit, this nerve is placed more or less between the other two branches of the eighth, being usually contained in the same neurilema with the spinal-accessory, but separated by a process of dura mater from the glosso-pharyngeal. Exit.

On its emergence, we find the fasciculi of the par vagum united into a firm cord, and interlaced so as to form a greyish gangliform enlargement: here also the whole of the eighth and ninth pair are intimately connected by cellular tissue. At first, the pneumogastric is anterior and external to the lingual-motor nerve, but soon passes behind it and descends along the neck to the thorax, which it traverses, and then passing the diaphragm, terminates in the abdomen. Let us first notice its position and trace its connexions throughout its whole course; and then describe its branches. Position.

In the neck it lies upon the rectus capitis anticus major and longus colli muscles: it is first found anterior to the jugular vein; but subsequently winding to its posterior and inner part, descends in the sheath between this vessel and the carotid artery,—having parallel and anterior to it the descending branch of the lingual motor nerve, and lying upon the cervical ganglia and their branches. Course.

The two nerves now enter the *thorax*: here, however, the relation of analogous parts on either side of the median line not being identical, a separate description of each nerve is requisite[1].

Left side. At the lower part of the neck on the *left* side, the nerve is found on a plane posterior to that on the right, being parallel to and between the subclavian and carotid arteries in their vertical course: having reached the aorta, it passes along the outer surface of the descending portion of the arch, crossing obliquely the origin of the subclavian artery of the same side.

Right side. On the *right* side, the nerve crosses at a right angle between the subclavian artery and vein, and internal to the anterior scalenus muscle. We find the two nerves then inclining backwards, approaching the median line as they descend; and passing from the side of the trachea behind the roots of the lungs, they enter the posterior mediastinum. They now become attached to the œsophagus, the left on its anterior, the right on its posterior surface, and thus reach the muscular opening in the diaphragm, which transmits them together with this tube into the abdomen; and here they

[1] Before these nerves are dissected, the course of the aorta and relative position of the three branches derived from the arch should be carefully reviewed; and notice taken of the mode of junction of the subclavian and jugular veins of either side, and the subsequent union of the two venæ innominatæ to form the descending cava.

spread out on the stomach into their terminating filaments.

Branches. In the foramen lacerum and immediately external to it, the vagus nerve communicates with the glosso-pharyngeal, spinal-accessory, and lingual-motor nerves, and superior cervical ganglion. Branches.

Pharyngeal nerve. Shortly after the trunk leaves the cranium this branch is given off. It crosses close to the spine, first behind the internal and then behind the external carotid artery, directing itself downwards and inwards to reach the side of the pharynx: in this course it usually receives a filament from the spinal accessory, and opposite the upper part of the middle pharyngeal constrictor divides into many filaments, which communicate with fine twigs from the glosso-pharyngeal and superior laryngeal nerves, and upper cervical ganglion: the resulting interlacement is named the *Pharyngeal plexus*; and from this source, the muscular and mucous tissues of the pharynx are supplied. Pharyngeal. Plexus.

Superior Laryngeal nerve. This arises usually a very short distance below the last, and takes an arched course behind the carotid vessels and before the lower extremity of the superior cervical ganglion, and soon divides into an external and internal branch: previously to this, however, it sends filaments of communication to the above-mentioned ganglion and the lingual-motor nerve; Superior laryngeal.

and assists, as already noticed, in the formation of the pharyngeal plexus. The *external* branch, on reaching the side of the larynx, divides into filaments which are distributed to the thyro-hyoid, sterno-thyroid, and crico-thyroid muscles, and neighbouring part of the lower pharyngeal constrictor, and a few penetrate the crico-thyroid membrane. The *internal* branch also passes inwards to the side of the larynx, and descending to the interval between the thyroid cartilage and os hyoides, penetrates the connecting membrane of these bodies, and immediately divides into ascending and descending filaments, the former being distributed to the epiglottis and neighbouring mucous membrane of the pharynx; whilst the latter, which are more numerous, supply the mucous membrane about the arytenoid cartilages and rima glottidis, and give filaments to the arytenoid and crico-thyroid muscles. An anastomosis between these and the filaments of the inferior laryngeal nerve occurs in the laryngeal mucous membrane.

External.

Internal.

The next filaments the vagus gives off are small and irregular: some communicate with the cervical plexus, and others pass to the internal carotid artery. Previous to entering the thorax, the *cardiac* branches are detached: those of the two sides are not symmetrical, nor are they regular in number or size; the following is the ordinary distribution; three or four filaments

Cardiac.

are separated from the right nerve usually at no great distance above the origin of the carotid artery of the same side; they descend along the outer side of this vessel to the innominata, by which they are conducted to the cardiac plexus where they terminate. Only one cardiac branch is usually supplied by the nerve of the left side; this is also conducted by the corresponding carotid artery to the aortic arch, where it joins the above-mentioned plexus[1].

Inferior or *Recurrent Laryngeal* nerves. Each of these branches is derived from the trunk of the pneumogastric just as it enters the thorax: they differ on the two sides, principally in their origin, partly in their distribution. We will first describe the right branch, and then notice the deviations from this description on the left side. Directly after the *right* vagus has crossed the subclavian artery, the recurrent nerve is given off; it immediately passes backwards, at the same time inclining towards the median line, and then directs itself upwards behind this vessel, so as nearly to surround it; subsequently it is found gliding beneath the common carotid and inferior thyroideal arteries, and thus arrives at the side of the trachea: in this course it lies internal to the sympathetic and phrenic nerves, and reaches the larynx

Inferior laryngeal.

Right side.

[1] These plexus are principally formed by branches from the cervical ganglia: the filaments from the vagus are accessory. See *Cardiac plexus*, in the Sympathetic System.

by running in the angular interval between the trachea and œsophagus, being at the latter part overlapped by the thyroid gland. This nerve first gives filaments to join the cardiac plexus; it next receives one or more small twigs of communication from the internal branches of the inferior cervical ganglion: as it ascends, the trachea, œsophagus, and thyroid gland each receive filaments which terminate respectively by supplying these structures,—some few piercing the membranous part of the trachea, are distributed to its mucous membrane. It now passes beneath the lower margin of the inferior pharyngeal constrictor, which receives some twigs, and thus reaches the posterior part of the thyroid cartilage, where it divides into its terminating filaments: one is lost in the mucous membrane of the pharynx; the rest, piercing the crico-thyroid membrane, supply the crico-arytenoideus lateralis and posticus, and thyro-arytenoideus; and spread out on the mucous membrane of the larynx, communicating with those of the opposite side, and with similar filaments of the superior laryngeal nerve, as already noticed.

Branches.

Left side.

The *left* recurrent nerve differs from the right in the following points:—it arises lower in the chest, viz. whilst the pneumogastric trunk is opposite the superior margin of the aortic arch, and is therefore the longer of the two; it winds round the arch of the aorta and ligamentous remains of the ductus arteriosus, passing external and posterior to the latter; and is next found between the transverse portion of the arch and the trachea; lastly, as it ascends it rests on the œsophagus, which, it will be remembered, inclines here to the left of the median line: these differences are accounted for by the course which the aorta takes, and the resulting relative position of its arch and the left pneumogastric trunk, as already described. Further, it may be remarked that the left recurrent nerve, whilst behind the aorta, detaches some filaments to communicate with the anterior pulmonary plexus; and that its cardiac branches chiefly join the posterior cardiac plexus. Relation.

We have already noticed the course of the pneumogastric nerves through the chest,—how they pass the roots of the lungs to reach the œsophagus, and are thence conducted to the stomach: now in this descent, the nerves lose for a time their cord-like character at different parts, by dividing and subdividing into innumerable interlacing branches which form plexus; such are the pulmonic and œsophageal plexus, which may be described to the following effect:—the two nervous trunks having reached the bifurcation of the trachea, first detach a few small filaments, which passing before the pulmonary vessels, interlace on their anterior surface and accompany them into the lungs. The nerves now become Plexus. Anterior pulmonic.

flattened and expanded, and on passing posterior to the bronchi, their fibres separate and again unite at intervals; this occurs again and again till a complete network is formed behind the root of each lung, containing in its meshes vessels and lymphatic glands, all held together by cellular tissue; this, the great or *posterior pulmonic plexus*, receives filaments of communication from the anterior plexus of the same name, from the cardiac plexus, and from the inferior cervical and first thoracic ganglia: the derived branches accompany the ramifications of the bronchi, supplying the lining mucous membrane, without appearing, as Cloquet observes, to belong to the parenchymatous tissue or blood-vessels of the lung.

Posterior pulmonic.

We now find filaments issuing from the inferior part of each plexus, and the corresponding nerve is again formed by their union, which does not take place immediately, but in a plexiform manner. The left then continuing on the anterior part of the œsophagus, holds this position throughout its course; whilst the nerve of the right side inclines to its posterior aspect, and is thus conducted to the diaphragm. Through the chest these cords are flattened, and by their frequent divisions and communications around the œsophagus, form the plexus gulæ, by which this muscular tube is principally supplied: some filaments appear to terminate in the aorta.

Œsophageal.

The two nerves now approach the diaphragm, becoming again collected, each into a more or less uniform bundle, as they are transmitted by the œsophageal opening into the abdomen. Here their relative position remains the same; the right, which is the larger trunk, continuing posterior to the œsophagus; whilst the left passes along its anterior surface to the stomach. Their ultimate distribution takes place as follows:—The *right* nerve having formed, by the division and interlacement of its branches, a network which nearly surrounds the cardia, proceeds beneath its peritoneal tunic along the posterior surface and both curvatures of the stomach, to the structure of which parts filaments are distributed, even as far as the pylorus: other and considerable filaments are disengaged to join the cœliac plexus, and, conducted by the branches of the arterial axis, find their way in company with the filaments of the sympathetic to the liver, spleen, pancreas, and duodenum. The *left* nerve, after assisting in forming a plexus around the cardia, distributes its branches along the anterior surface and smaller curvature of the stomach: filaments from this nerve also find their way between the layers of the lesser omentum, to join the hepatic and solar plexus. There is, moreover, a free communication between the nerves of either side along the smaller curvature, and on other parts of the stomach.

Right nerve.

Left nerve.

Communications.

Communications. By filaments from the trunk, with the glosso-pharyngeal, spinal-accessory, and lingual-motor nerves, and superior cervical ganglion; by its pharyngeal branch with the other branches of the eighth, and pharyngeal plexus; by its superior laryngeal branch with the superior cervical ganglion, lingual-motor, and inferior laryngeal nerves; by filaments from the trunk with the cervical and cardiac plexus. The different plexus in the chest and abdomen, moreover, communicate freely, forming an intimate association between branches of the vagus of either side and the sympathetic nerves.

Function.

Function. The pneumogastric are excito-motory nerves, and more particularly connected with the respiratory division of this system. They are, moreover, ganglionic nerves, i. e. they present a bulging and compact plexiform arrangement of their fibres immediately after leaving the skull[1], and are classed by Dr. Hall amongst the external nutrient nerves. In their long course and extensive distribution, they supply muscular, mucous, and glandular textures, presiding over some of their functions and influencing others; preserving the sympathy so necessary between the different

[1] I have also shewn, in some instances, a distinct elongated greyish swelling of the nerve, commencing about an inch below the lacerated foramen, being more than half an inch in extent, and giving off the superior laryngeal nerve. I believe this has been observed by others as well as myself.

parts of the respiratory apparatus to which they are distributed, and being no doubt the source of the appropriate sensibility of the organs which they supply. But the present subject must not be dismissed with so summary a notice: the physiological interest and practical importance which are necessarily attached to nerves whose distribution is so extensive and diversified, demand a more detailed inquiry into their probable functions. The order which it is intended to follow in this inquiry will be, to devote attention briefly to the larynx, lungs, heart, and stomach, as severally influenced by the paria vaga; and the student is requested to bear in mind that many of the deductions given here, as elsewhere, are but opinions, and to receive them as such.

Larynx. In viewing the laryngeal nerves in connexion with the muscles they supply, it does not appear that the distribution of the former is influenced by the peculiar actions which the latter are required to perform; or, to be more explicit, that the distribution of the one nerve is not *confined* to the constrictors, nor that of the other to the dilators, of the rima glottidis. Neither is there any reason why we should expect such to be the case, seeing that the nerves themselves are but branches of the same trunk, and therefore do not either, in all probability, possess any individual peculiarity of function[2]. The muscles, how-

Physiology. Larynx.

[2] I cannot say I ever understood what could be the object of trying to make good the opposite opinion: it certainly in-

ever, which command the opening of the glottis, are more especially supplied by the recurrent nerves; therefore, as we might infer, the voice is more effectually interfered with by division of these than of the superior laryngeal branches[1].

With respect to the further function of these nerves, as explained by their distribution to the laryngeal and tracheal mucous membrane, we have remarkable evidence of their connexion with the respiratory system. The high degree of irritability of the lining tissue of these parts is supremely necessary to the proper performance of their function, by carefully guarding against the admission of any foreign body, or by speedily causing the ejection of such body, if admitted into the air-tube. That here their office ceases, and that the function of secretion is under the direction of the sympathetic system, seems more than probable, both from analogy and the direct experiments of Brachet and others[2].

volves no physiological law, whether these several nerves exclusively supply antagonist muscles, or otherwise.

[1] Sir Charles Bell remarks, "Both laryngeal nerves are necessary to the formation of the voice. Experiments have been made upon them in dogs, and the result is curious; although the lesser changes of the strength, acuteness, and modulation of the voice could not be well observed in the lower animals. When the superior nerve is cut, the voice is feeble, but acute; when the recurrent nerve is cut, there is a relaxation of those muscles moving the arytenoid cartilages which command the opening of the glottis, and in consequence the voice is flatter and graver, or more raucous." (Bell's Anatomy, vol. ii. p. 552.)

[2] See further on, the remarks on the gastric filaments of the

Lungs. We now come to consider the function of the pneumogastric nerves, as connected with the lungs. These organs receive their nervous supply from two sources,—from the brain through the medium of the eighth pair, and from the sympathetic system. If the student have already dissected the nerves supplying the muscles of respiration, he will not fail to remember that they are partly cerebral[3], and in part spinal; or, to speak more correctly, according to the principles laid down in the physiological section, that they are 'proper cerebral or voluntary,' and 'true spinal or excito-motory.' It were superfluous to insist on the necessary existence of a mutual understanding, so to express it, between these muscles and the organs on which they mediately act; and it is equally palpable that such understanding can only be established by means of nervous communication between the lungs and the cerebro-spinal centre. Such, then, appears to be the office of the '*excitor portion*' of the pneumogastric nerves, to transmit to the brain—not the indefinite sensation implied by the terms 'necessity or need of Lungs.

pneumogastric, where references will be given to Brachet's experiments.

[3] The student is reminded that the term 'cerebral' by no means implies that the nerve so named arises from the cerebrum, but merely comprehends those nerves which pass out of the skull; hence one of the glaring evils which has its origin in the present objectionable nomenclature. This matter may be better understood by referring to the tables at the end of this section.

respiration'[1]—but the actual impression made on the lining membrane of the air-passages by the contact of carbonic acid gas.

Bronchi. Further, these nerves supply the mucous membrane of the bronchial tubes; and here we have them performing the same function as that already alluded to in the distribution of the laryngeal nerves[2]. The division of the pneumogastric trunks is followed by loss of irritability through the whole extent of the lining membrane of the air-passages[3]. Lastly, the decarbonization of the blood appears to be uninfluenced by these nerves; their division, so long as respiration is continued, giving rise to no apparent interruption of this process[4].

It may be remarked, that no notice has been taken of the source from which the general mass of the lungs receives its nerves. There can be little doubt that the less sensible or parenchymatous portion of these organs is supplied from the sympathetic and eighth pair, as well as the more highly endowed membrane of the air-tube.

[1] '*Besoin de respirer*' is Brachet's term, and '*necessity*' is the equally inexplicative word employed by other authors. The surmise of Dr. Hall has rendered it at any rate probable that the former explanation was one step further removed from the proximate cause.

[2] *Recherches expérimentales sur les Fonctions du Système nerveux ganglionaire*, par J. L. Brachet, 1834. See Experiments 32 and six following.

[3] Id., Experiments 46 and 47.

[4] Id., Experiment 51.

That the structure of the lung is comparatively insensible, even when inflamed, is true; but there is a wide difference, as Sir Charles Bell observes, "between the common sensibility and the appropriate sensibility of an organ."

We should not omit to notice that the irritability of the air-tubes, as evinced by the intrusion of extraneous matter, is greatest about the inlet, i. e. in the neighbourhood of the glottis and rima, and therefore proportionate to the quantity of nerves distributed[5].

The *Heart* is supplied by branches from the pneumogastric nerves, but it also derives its supply in part from the sympathetic. Now the heart is an *involuntary* muscle in the fullest meaning of the term, i. e. not only acting quite independently of the will under ordinary circumstances, but in no way subjected to the direct influence of the will at any time. It is unlikely, arguing *à priori*, that the action of such a muscle would be directed by nerves, the distribution and functions of which have been shown to be such as belong to the Heart.

[5] We know this fact experimentally; for a foreign body may rest in one of the bronchi, or their smaller ramifications, and excite, *comparatively*, but feeble efforts for its expulsion. In the foregoing description the reader is requested to make the necessary distinction between 'irritability' and 'sensibility'; both words are employed to signify the meaning which is strictly attached to them. Any degree of *sensibility* about the upper part of the larynx may be owing to the presence of filaments of the lingual branch of the fifth nerve.

pneumogastrics[1]. Experiment and analogy seem to prove that the cardiac branches of the sympathetic endow this organ with irritability, which renders it susceptible of being stimulated to contraction by the presence of the blood, &c.: this subject is, however, treated of elsewhere[2]. Further, the heart is perfectly *insensible* in its natural state[3]; for what then does the vagus send its supply to this viscus? We have here a central organ of the first importance, upon the healthy action of which every other organ, whether far or near, is more or less dependent, through the medium of the circulation, for its individual vitality and subsistence. This fountain-head of the circulation should hold some communication with every part of the system, and more especially the respiratory and digestive organs; and that such communication does exist, pathology presents us with numberless facts to prove; as witnessed by the marked derangement of the circulation which results from even the most trivial disturbing causes. But how paramount is it that a reciprocal influence should be maintained between the brain and

[1] Experiments performed by many able physiologists concur in proving that the heart will act even for days after division of the pneumogastric nerves; and further, that destruction of the brain and spinal marrow does not necessarily or at once put a stop to the action of this viscus. For a detailed account, the reader is referred to some systematic work on physiology.

[2] See 'Cardiac plexus,' under the division 'Sympathetic.'

[3] See Richerand's Physiology by Copland, Appendix, p. 616.

heart! *This* then appears to be the office of the pneumogastric nerves as regards their cardiac distribution; to communicate *directly* between the centre of the circulation and the centre of the cerebro-spinal nerves; and *indirectly*, through the medium of the latter, with distant organs. Not that it is meant to exclude the sympathetic from partaking of the more general of these functions: the intricate interlacement between the cardiac branches from the two different sources would seem to imply that their duties must be to a certain extent in common; and, as before noticed, pathology and experiment teach us the converse, viz. that privation or impairment of the accustomed and necessary influence of the brain produces irregular contraction of the heart and disordered circulation[4].

Of the organs of *Digestion* in the abdomen, the glandular and upper part of the membranous Abdomen.

[4] Here allusion is made of course only to the direct agency of such mutilation: the certain and comparatively speedy annihilation of the heart's function after removal of the *brain* is really only a collateral mode of effecting this object, and dependent on secondary causes; for the result even of a far slighter injury than this would, by a constantly reacting or reciprocal derangement, go on in a rapidly increasing ratio to the death of all the organs which might be directly or indirectly involved in the primary mischief. With respect to the local *sympathy* that exists between any structure and its vessels, is it not more than probable that the same nerves supply both; and that, moreover, the filaments of the sympathetic system extend along the arteries to their terminations, so as to control the *action* even of the capillaries?

viscera receive in part their nervous supply from the pneumogastrics. If it be admitted, as is most probably true, that the sympathetic system presides over the secretions, there will then be but little need of further supply to the *glandular* viscera; and accordingly we find that the filaments derived from the eighth pair are comparatively small and few, but such as are sufficient to preserve the sympathy between these and other organs, and particularly the brain. But the large supply which passes exclusively to the *stomach*, would seem to indicate that other and important functions possessed by this viscus are under the control of the cerebral, or true spinal system. Let us examine what they may be.

Stomach. The *stomach* is the seat of the peculiar sensations of *hunger* and *thirst*, which may be styled 'forms of the *appropriate sensibility*' of this organ. Of course this sensibility implies the existence of nerves, and analogy would lead us to infer that it was referable to the cerebral system: the investigations of Brachet present us with experimental evidence corroborative of this conjecture[1]. We may therefore conclude, that it is to the distribution of the pneumogastric nerves to the mucous membrane of the stomach that we are indebted for those necessary warnings to protect us against the injurious effects of long abstinence.

[1] Brachet, *Recherches*, &c., Experiments 52 and 53.

The stomach is endowed with muscular power, and capable of contracting on its contents. It may be matter of question whether such contraction be at all under the influence of the will; if so, this voluntary power could only be derived from the pneumogastrics. But be that as it may, the chief action of the muscular tunic of the stomach is subservient to digestion, and completely independent of the will: the reasons why the sympathetic is supposed to be in this case the controlling power, are submitted to the reader in the remarks at the conclusion of that system. It is true that division of the pneumogastrics renders the stomach incapable of rejecting its contents; but surely, as elsewhere explained[2], the cause of this must be sought, not in paralysis of the muscular coat of the stomach, but rather in the destruction of the circle by which the abdominal muscles, &c. are excited to action[3]: besides, the

[2] See conclusion of the Sympathetic system,—remarks on the nervous supply of the stomach.

[3] Other considerations assist in supporting the probability of this explanation. Let us trace the different steps by which the act of vomiting is effected. The chest is first of all more or less dilated by the descent of the diaphragm, and this is immediately succeeded by closure of the glottis: the contraction of the diaphragm now ceases; but it remains fixed, and is not allowed to ascend in consequence of the expanded condition of the lungs: a double object is gained by this; the muscular ring around the cardia is relaxed, at the same time that an unyielding surface is presented, against which the stomach may be compressed by the abdominal muscles. Now the closure of the glottis is a point of much interest as connected with the

connexion between the appropriate sensibility of an organ and its contractility, even though not referable to the same centre or axis, is such as to render the latter property in some measure dependent on the unimpaired condition of the former.

Digestion. In examining the pneumogastric nerves in connexion with the subject of *digestion*, the conclusions at which we arrive are not altogether satisfactory. It may be stated on the authority of Brodie, Brachet, and others, that division of these nerves on the stomach does not interrupt the formation of chyme or chyle; and according to Breschet, Edwards, and Vavasseur, section of the nerves in the neck only retarded the process of digestion[1]. From what has already been stated in a previous division of our subject, one might

subject under consideration: it is as essential to the act of vomiting as the ascent of the larynx is to swallowing: it is not an act of the will; without it we could not vomit. It is therefore as unphilosophical as it is unsatisfactory to receive as an explanation, "that it is *necessary* the glottis should be closed, otherwise extraneous matter would pass into it." We see here a *consent* of parts, which implies that there is one and the same influencing power, and consequently but one and the same impression, by which the act of vomiting and the concurrent closure of the glottis are effected.

[1] These latter physiologists remarked that section with loss of substance of these nerves interfered much more materially than *simple section* with the process of digestion. (*Archives Générales de Médecine*, Août 1823.) Reference is made to these experiments, and the inferences are stated in the Appendix to Dr. Copland's translation of Richerand's Physiology, whence this notice is extracted.

have inferred *à priori* that such consequences would result from cutting off the communication which this viscus holds directly with the brain, and indirectly, i. e. through the medium of the brain, with other organs which afford collateral assistance to its functions. It would be incompatible with our limits to enter into a physiological discussion on this subject; we shall therefore dismiss it with noticing a remark made by the physiologists last mentioned, "that narcotics, administered so as to produce coma, considerably diminish the energy of the digestive powers." This consequence may be dependent upon an impaired condition of the functions of either system supplying the stomach.

Lastly, independently of the universal sympathy which so remarkably characterizes the various organs, whether in health or disease, to which these nerves are distributed, there can be no doubt that to maintain the peculiar sympathy between the stomach and brain is one of the functions of the pneumogastric division of the eighth pair. To bring forward proofs of the fact and evidence of this sympathy would be superfluous: suffice it to remind the reader of the effects of indigestible matters of all sorts, alcohol, narcotic medicines, as severally inducing headache[2], suspension of the intellectual faculties, Sympathy.

[2] It is not here meant to imply that the brain itself is the

coma, &c.; and on the other hand of vomiting, as so constant an attendant of concussion of the brain, &c.

Practical remarks.

After this brief physiological review of the pneumogastric nerves—the *paria vaga* as they have been aptly called—it seems almost unnecessary to impress on the student the many points of practical importance connected with their distribution. In nearly every internal disease he has to combat he will meet with derangement of some organ which receives more or less of its supply from these nerves. In their communications may be traced the frequent and complicated disorders of the respiratory apparatus, which, though probably sympathetic and purely functional, so nearly simulate serious local affections as to lead to a supposition of the existence of organic disease[1]. Before quitting the subject, we shall give a brief summary of the operations likely to interfere with these nerves.

Mr. Burns remarks, that "from the locality of tumors produced by enlargement of the glandulæ concatenatæ, respiration and deglutition are soon

seat of pain, nor is it clear that the other instances quoted are *necessarily* the results of a *direct* sympathetic agency; they, however, sufficiently illustrate our subject. The most common seat of what we call "headache" is the supra-orbitar branch of the ophthalmic nerve.

[1] Further observations on this subject will be found in the exposition of the excito-motory system. See Physiological section.

affected; and it will generally be found, that by the pressure of the swelling on the nervus vagus and sympathetic nerve, the functions of the chylopoietic viscera are impaired[2]." It is probable that to a certain extent this statement is correct, but most of these symptoms may be in some measure accounted for by mechanical pressure on the parts concerned in deglutition and respiration, and the concomitant functional derangement of organs, dependent on the disease. In instances of this sort, Nature exerts her power of adaptation to circumstances; and vital parts, such as nerves and arteries, have their functions much less impeded than might be expected. These nerves are sometimes found traversing the centre of tumors of the character alluded to.

The position of the vagus nerve in the neck Operations. need hardly be indicated as a point of relative anatomy which the operator should be mindful of in passing a ligature round the common carotid: it lies within the sheath, and between the artery and vein. Again, the relation of the vagus and its branches lower down does not render them liable to injury in the ordinary operation of tying the subclavian artery, i. e. after it has passed the scalenus muscle: but in case of the necessity of performing this operation on the right side internal to the scalenus, both the nervous trunk and its recurrent branch must be turned aside. In

[2] Anatomy of the Head and Neck.

the operation of œsophagotomy, for which the left side is selected in consequence of the tendency of the œsophagus in that direction from the median line, the left recurrent nerve is found, just previous to its ultimate distribution, resting on this tube: it is therefore in danger of division unless the operator search for and displace it before the final incision is made.

SPINAL ACCESSORY NERVES[1]. *Third division of the Eighth.*

Spinal accessory.

The usual origin of these nerves is by a series of filaments which commence a little below the par vagum, and extend as low as the fourth cervical nerve; taking root from a continuation of the same track as gives rise to the other divisions

[1] Or "superior external respiratory nerves" of Bell, and eleventh cerebral nerve of Arnold and others. The origin of this nerve is very variously given by different authors: by some it is described as not descending below the third cervical, and by one it is traced even to the third dorsal pair. (Frotschez, *Descriptio Medullæ Spinalis*, p. 21., quoted from Bellingeri.) Scarpa, Willis, and Vieussens also differ upon this subject. Its relations to the anterior and posterior roots of the spinal nerves is also variously described; some, as Gall, tracing its filaments actually from the latter. Bellingeri concludes from his dissections of this nerve in the ox that it always arises from the lateral fasciculi of the spinal marrow, but that it is unconnected to the posterior spinal roots. The probability is that it differs much as to height of origin in different subjects; indeed, Cloquet says it sometimes differs on the two sides of the same subject. (See Bellingeri, *De Medullâ Spinali Nervisque*; Cloquet's Anatomy, &c.)

of the eighth, viz. between the anterior and posterior origins of the spinal nerves. The trunk of each thus formed passes up immediately behind the ligamentum dentatum, increasing in bulk as it ascends: it then enters the skull by the occipital foramen, and proceeds outwards and forwards to the posterior lacerated foramen, by which it leaves the cranium. As it passes into the skull, this nerve lies behind the vertebral artery and communicates with the suboccipital, and often with the first cervical, nerves. In the base of the cranium, near the posterior lacerated foramen, it is found beneath the par vagum; and becoming invested by the fibrous sheath of dura mater common to it and this last nerve, it leaves the skull posterior to the other two divisions of the eighth pair. The sterno-mastoid and digastric muscles being turned aside, the subsequent course of the accessory nerve is exposed. On quitting its connexion with the par vagum, this nerve adheres to the outer side of the lingual-motor, parallel to which it runs for a short distance, and then emerging from behind the jugular vein it soon penetrates the inner aspect of the sterno-mastoid muscle in its upper third[1]. Its course is now obliquely downwards and backwards through the fibres of this muscle, from the posterior margin

[1] Occasionally, though but rarely, this nerve passes posterior to instead of perforating the muscle.

of which it issues, and immediately passes beneath the trapezius in which it terminates.

Branches. We first find this nerve communicating with the pneumogastric just after their joint exit from the skull, and subsequently by a smaller filament with the lingual-motor nerve: the pharyngeal plexus then receives a twig, and branches are supplied to the sterno-mastoid as it is traversed. Considerable filaments of communication pass between it and the cervical plexus, and at last it is distributed to the upper part principally of the trapezius muscle.

Communications. *Communications.* In its ascent to the skull, with the sub-occipital and first cervical; with the pneumogastric and lingual-motor nerves, at its exit; and in its course, with the pharyngeal and cervical plexus.

Function. *Function.* The experiments of Sir Charles Bell prove that this nerve is peculiarly connected in its office with the respiratory property of the muscles it supplies. The sterno-mastoid and trapezius muscles are agents, chiefly indirect, in inspiration, and it is the function of the spinal accessory nerve to preside over this action. When the scapulæ are approximated, and the clavicles drawn upwards or fixed, other and much more direct and powerful agents, as the lesser pectoral and great serratus, are enabled to act from their comparatively fixed insertions upon their line of origin, and thus perform their part in forcible inspiration. Division of the accessory nerve is not followed by paralysis of the muscles to which it is distributed, because they are also supplied by other nerves: they remain under the direction of the will, but cease to be influenced by the lungs[1].

This nerve is not likely to be interfered with in any ordinary surgical operation[2].

LINGUAL-MOTOR NERVES. *Ninth pair*[3].

Each nerve of this pair arises by ten or twelve distinct and delicate filaments from the fissure in the medulla oblongata which separates the corpus pyramidale from the olivare: this, it will be remembered, is continuous with the groove from Lingual-motor.

[1] Sir Charles Bell's Experiments.

[2] It may be well, in concluding the description of those nerves which are said more particularly to influence the respiratory muscles, to warn the student against allowing his notions upon this subject to be too confined;—by which I mean, that he should not carry away the impression that those muscles only which are said to be supplied by respiratory nerves, are agents in respiration. If he review the muscles of the trunk, he will find but few which may not in some way or other be *excited* to play a part in the extended and varied operations of the all-important act of respiration. The simple effort of the abdominal muscles in coughing or sneezing cannot be made without the consentaneous action of the sphincters of the anus and urethra to close these outlets. Surely such cooperation speaks for itself: the same nervous influence presides over both; and we cannot deny to these sphincters their place in the respiratory—or, to speak more correctly, in the excito-motory—system.

[3] Or twelfth cerebral pair of some authors.

which the anterior or motor roots of the spinal nerves arise. Occasionally these filaments are found forming two bundles which subsequently join; but they are usually united at once into one cord, which, receiving its neurilema, passes downwards and outwards to the anterior condyloid foramen, by which it makes its exit from the skull. At its origin the fibres of this nerve are crossed anteriorly by the vertebral artery. Immediately on leaving the skull it becomes slightly enlarged, and is connected to the par vagum—to which it is posterior and internal—by a dense sheath of cellular tissue[1]. As it descends forwards it also becomes more superficial, hooking round the occipital artery near its origin, and then crossing external to the par vagum, superior cervical ganglion, and both external and internal carotid arteries: it has, however, superficial to it the digastric and stylo-hyoid muscles, and the ~~internal~~ * jugular vein. In the first part of its course, it usually communicates with the pneumogastric and sub-occipital nerves, and superior cervical ganglion. It now emerges from the cover of the digastric muscle, and forming a small arch or loop, turns upwards and forwards to disappear between

[1] In one instance I saw these two nerves contained in the same fibrous neurilema for more than an inch after their exit from the skull: they were so inseparably connected that maceration alone proved that there was no considerable interchange of fibres.

External

the mylo-hyoid and hyo-glossus muscles. Previously to describing this last part of its course and its distribution, the attention must be turned to its descending cervical branch.

Descendens lingualis. This branch is given off from the lingual-motor nerve just previous to its crossing the external carotid artery: the bundle of filaments which form it are occasionally separable to a greater extent along the trunk. Having been joined (as is frequently the case) by a filament from the par vagum[2], it descends along the carotid sheath, usually external but sometimes internal to it, and under cover of the sterno-mastoid muscle. Opposite the point of intersection of the omo-hyoid and sterno-mastoid muscles this nerve terminates by anastomosing with the deep anterior communicating branch of the cervical plexus. The result of this union is a small triangular network or plexus, from which are derived branches that are distributed to the omo-hyoid, sterno-hyoid, and sterno-thyroid muscles. Not infrequently a filament may be traced along this last muscle, which descending into the chest communicates with the phrenic. Descenden noni.

We now proceed to trace the trunk of the ninth nerve to its termination. The loop which it forms, as already noticed, descends below the digastric Continuation of trunk.

[2] Filaments of equal size from the lingual and pneumogastric sometimes form this descending branch: I have even seen the larger filament derived from the latter trunk.

tendon, and at this part the nerve is most superficial, being only covered by the platisma and fascia: but then directing its course forwards and upwards, it passes above the mylo-hyoideus, and between it and the hyo-glossus. Whilst crossing the latter muscle, the fibres of the nerve become more expanded, and branches are given off to the mylo-hyoideus and hyo-glossus; also to the genio-hyoideus, thyro-hyoideus, genio-hyo-glossus, stylo-pharyngeus, and constrictor pharyngis superior. It is here likewise that a free communication takes place between this nerve and the lingual branch of the fifth; its mylo-hyoidean twig moreover communicates with the filament of the same name derived from the inferior dental nerve: no anastomosis, however, appears to exist between any of the branches of this nerve and the glosso-pharyngeal.

Branches.

After quitting the hyo-glossus we find the nerve, which is now much diminished in size, accompanying the lingual artery between the genio-hyo-glossus and lingualis muscles towards the apex of the tongue: it expends itself in branches which are distributed to the muscular structure forming the superficial portion of this organ; but none can be traced into the mucous membrane.

Communi-cations.

Communications. In the first part of its course, with the par vagum, superior cervical ganglion, and suboccipital nerve; by its descending branch, with the cervical plexus, and frequently with the pneumogastric and phrenic nerves; by its terminating filaments, with the lingual branch of the fifth, and the mylo-hyoidean filament of the inferior dental.

Function. Whatever may be the question respecting the other two nerves of the tongue, there is no doubt that this is the motor nerve of that organ. Further, granting that the supposition respecting the gustatory function of the glosso-pharyngeal nerve is correct, it will be seen that the lingual-motor nerve is fully capable of performing the office previously ascribed to the former, viz. that it is also the nerve of deglutition; a fact which its anatomical distribution alone renders highly probable. This, however, be it remembered, is an *excited* and very complicated act, though so simple in its effects as scarcely at first to arrest attention: there is a consent and cooperation of parts which implies that deglutition is something more than a merely voluntary action[1]. Function.

[1] It were unnecessary to quote authorities in proof of the ninth or hypo-glossal being the motor nerve of the tongue: the reader may, however, refer to the paper before quoted of Professor Panizza, from which it is intended to give one more extract, in support of the lingual-motor being also the nerve of deglutition. "By division of the hypoglossal nerves not only were the voluntary motions of the tongue and those which aid mastication destroyed, but the motions which contribute to deglutition were also annihilated.... A morsel of food being placed on the *dorsum* of the animal's tongue and left there, if the mass did not move by its own weight and by the motions of the lower jaw, and thence either dropped out or hung be-

Remarks. *Remarks.* The lingual-motor nerve has no communication with its fellow; therefore, in hemiplegia it is found that the muscles of one side only of the tongue are paralysed: the apparent anomaly, in these cases, of the apex of this organ, when protruded, pointing towards the affected side, is accounted for by the action of the genio-hyo-glossus muscle of the sound side, the tendency of which is, by approximating the base of the tongue to its own side, to project the apex in the opposite direction.

Operation. In case of hæmorrhage from wound or ulceration of the tongue, circumstances may render it advisable to tie the lingual artery: in such case, the position of this vessel relative to the lingual-motor nerve should be borne in mind: the former lies directly below and a little behind the latter, where they are opposite the tendon of the digastric muscle. The hyo-glossus subsequently intervenes between them, the nerve being the more

tween the tongue and teeth, it was found still in the same position after many hours. Deglutition was not completed unless when the alimentary mass was conveyed into the cavity of the *pharynx*, by the single action of the pharyngeal muscles; but even in this case it was imperfect; because, as I have often ascertained, the mass compressed by those muscles is decomposed, and returns in part into the mouth by the *isthmus faucium*, which the paralytic tongue is unable to shut. The same result ensues, if, in order to cause the dog to drink, fluid is poured into his fauces; and hence it costs considerable time and patience to continue him in life."

The reader will find more ample remarks on the subject of deglutition, in the Physiological section.

superficial; and this muscle being passed, they continue in company to their termination.

Peculiarities.

The commencement of the lingual-motor nerve is not always regular as to the number of its fasciculi or the exact extent of their origin: some are frequently derived even a little distance below the olivary body[1].

[1] In watching the progress of death, in the sheep for instance, where all sensation and voluntary power must rapidly cease from division of the medulla spinalis and the copious bleeding, the later general convulsive tremors are usually accompanied by frequent spasmodic protrusion of the tongue.

Tabular View of the Distribution of the Cerebral Nerves.

1st. Olfactory.	External. . . . . . . To the membrane covering the turbinated bones.			
	Internal. . . . . . . To the septum nasi.			
2nd. Optic.	Forming the retina.			
3rd. Common oculo-muscular.	Superior division	Rectus superior. Levator palpebræ.		
	Inferior division	Rectus inferior. Rectus internus. Obliquus inferior.		
4th. Pathetic.	Superior oblique muscle of the eye.			
5th. Trigeminal.	1st division, Ophthalmic	Frontal......................	Supra-trochleator. Supra-orbitar.	
		Lachrymal	Communicating. Malar. Glandular. Palpebral.	
		Nasal	Communicating. Ciliary. Proper nasal. Infra-trochleator.	
	2nd division, Superior maxillary	Pterygo-maxillary	Orbitar......	Malar. Temporal.
			Communicating.	
			Posterior superior dental.	
		Infra-orbitar	Anterior superior dental.	
			Facial	Malar. Nasal. Palpebral. Labial.
	3rd division, Inferior maxillary	Muscular	Temporal. Masseteric. Buccal. Pterygoid.	
		Sensitive	Temporo-auricular. Inferior dental. Lingual.	

6th. Abducent.	External rectus muscle of the eye.		
1st of 7th. Facial.	In Fallopian aqueduct muscular to		Stapedius. Tensor tympani.
	Before great division.		Posterior auricular. Submastoid. Stylo-hyoid.
	Temporo-facial.		Temporal. Malar. Buccal.
	Cervico-facial.		Supra-mental, to cheek and lips. Infra-mental, to platisma and neck.
2nd of 7th. Auditory.	1. To spiral lamina, modiolus, &c. of cochlea. 2. To the vestibule and semicircular canals.		
1st of 8th. Glosso-pharyngeal.	Tympanitic. Communicating. Pharyngeal. Epiglottidean. Tonsillitic. Lingual.		
2nd of 8th. Pneumogastric.	Communicating.		
	Pharyngeal	Muscular and mucous tissues of pharynx.	
	Superior laryngeal	External.	Thyro-hyoid. Sterno-thyroid. Crico-thyroid. Arytenoid. Constrictor pharyngis inf.
		Internal.	To laryngeal membrane.
	Cardiac.		To heart.
	Inferior laryngeal.	External.	Constrictor pharyngis inf. Crico-arytenoid, lat. and post. Thyro-arytenoid.
		Internal.	To laryngeal membrane.
	Pulmonic plexus		To lungs.
	Œsophageal plexus		To œsophagus.
	Gastric		To stomach.
	Cœliac		To join the solar plexus, passing to liver, spleen, pancreas, &c.
3rd of 8th. Spinal accessory.	Communicating		Principally to cervical plexus.
	Muscular		To sterno-mastoid and trapezius.
9th. Lingual-motor.	Communicating. Descendens lingualis.		
	Muscular, to all the muscles of the tongue.		

Remarks have been made at different times, in the course of the preceding descriptions, upon the classification of the cerebral nerves, with a view to guard the student as much as possible against the confusion which is the natural consequence of unscientific arrangement and a various nomenclature. It is however, perhaps, not so easy to suggest a remedy as to find fault; but if a general view of the different classifications which have been adopted, together with their objectionable points, be laid before the student, it may serve as a means of enabling him to arrange his own information with more facility and precision.

According to the ordinary classifications, the term "cerebral," as applied to nerves, implies such as pass by foramina from the interior to the exterior of the skull, without any regard to their origin being *cerebral*, i. e. from the cerebrum, or indeed any part of the brain. It is on this principle that the two arrangements most commonly in use have been framed. (See Tables 1 and 2.) Some again have excluded the spinal accessory alone: we cannot see the object of this, since it is as much a *cerebral* nerve as any part of the eighth, i. e. not at all. Again, another and more correct classification is, according to the cerebral or spinal origin of the nerves[1]; still, however, as will be shown, open to objection. (Tab. 3.) A

[1] The medulla oblongata is understood as being a part of the spinal cord.

fourth arrangement would be according to their function; decidedly more scientific than any yet mentioned. (See Tab. 4.) But the only classification which can meet these objections is that adopted in *Table No. 5.*, where each nerve, whether in part or whole, is referred to the centre or axis, which is the source of its influence. This arrangement, it must be acknowledged, is a little complex at first sight, because there are so many of these nerves whose functions are compound. There is, however, no desire on our part to add to this complexity by assigning corresponding compound names explicative of function: this—though if generally adopted it would be advantageous,—is not *necessary*. Let all the nerves passing out of the skull be *described* as a section or division analogous to the cervical, lumbar plexus, &c.; but let them be *understood* according to Tables 4 and 5.[2]

[2] I am aware that there is nothing new in this: it is only hoped that these remarks and the subsequent tables may place the matter in a more striking light before the student.

NERVES PASSING OUT OF THE SKULL.

TABLE I.

Common classification. IX. Pairs [1].

1. Olfactory.	7. { Facial. / Auditory.
2. Optic.	8. { Glosso-pharyngeal. / Pneumogastric. / Spinal accessory.
3. Common oculo-muscular.	9. Lingual-motor.
4. Pathetic.	
5. Trigeminal.	
6. Abducent.	

TABLE II.

Classification of Arnold and others. XII. Pairs [2].

1. Olfactory.	7. Facial.
2. Optic.	8. Auditory.
3. Common oculo-muscular.	9. Glosso-pharyngeal.
4. Pathetic.	10. Pneumogastric.
5. Trigeminal.	11. Spinal accessory.
6. Abducent.	12. Lingual-motor.

TABLE III.

Classification according to origin.

Proper Cerebral.	1. Olfactory. 2. Optic. 3. Common oculo-muscular. 4. Pathetic.
Connected to the medulla oblongata.	5. Trigeminal. 6. Abducent. 7. Facial. 8. Auditory. 9. Glosso-pharyngeal. 10. Pneumogastric. 12. Lingual-motor. The spinal-accessory is a spinal nerve.

TABLE IV.

Classification according to function.

Specific sensibility.	1. Olfactory. 2. Optic. 8. Auditory. 9. Glosso-pharyngeal?
Common sensibility.	5. Ganglionic division of fifth.
Motor.	4. Pathetic. 3. Common oculo-muscular. 5. Non-ganglionic division of fifth. 6. Abducent. 7. Facial. 10. Pneumogastric. 12. Lingual-motor. 11. Spinal-accessory.

[1] According to Table I. all the nerves that pass out of the skull by one and the same foramen are classified together.
[2] Here each nerve is taken separately.

TABLE V.

Classification according to the Centre or Source of Influence.[1]

Proper cerebral nerves.	Of voluntary motion.	Common oculo-muscular.
		Pathetic.*
		Non-ganglionic division of fifth.
		Abducent.*
		Facial.*
		Pneumogastric.*
		Spinal-accessory.*
		Lingual-motor.
	Of common sensibility.	... Ganglionic portion of fifth.*
	Of specific sensibility.	Olfactory.
		Optic.
		Auditory.
		Glosso-pharyngeal. ?
True spinal or excito-motor nerves.	Motor.	Non-ganglionic portion of fifth.
		Pathetic.
		Abducent.
		Facial.
		Pneumogastric.
		Spinal-accessory.
		Lingual-motor.
	Excitor.	Ganglionic portion of fifth.
		Pneumogastric.

[1] Those marked with an asterisk are compound nerves, i. e. belonging also to the excito-motory system.

SECTION II.

SPINO-SACRAL NERVES.

The nerves proceeding from the spinal cord in its descent through the vertebro-sacral canal, consist of thirty pairs: eight cervical, twelve dorsal, five lumbar, five sacral. Their names are derived from, and consequently indicate, the regions opposite which they emerge from the canal. The following are the general characters in which they all agree.

General character.

1. They are symmetrical.

2. They arise from the spinal marrow by two roots, an anterior and posterior: these roots each consist of several filaments, and are separated at their origin by the side of the spinal cord and ligamentum dentatum[1]: the posterior root is almost invariably the larger, and expands into a small oval ganglion; the anterior root pierces the dura mater separately, and has no ganglion; of these, the posterior or ganglionic root is endowed

[1] Some of the filaments both of the anterior and posterior roots of the spinal nerves may be traced inwards, till they come in contact with the cornua of the cineritious substance. (Bellingeri, *De Medullâ Spinali Nervisque*, cap. iii. Art. 2.)

for sensation; the anterior or non-ganglionic for motion[2].

3. In their passage through the intervertebral foramen, immediately after the formation of the ganglion, the two roots unite to form a single cord, which then receives the name of 'spinal nerve.'

4. This trunk subsequently divides into two branches, an anterior and posterior: of these, the former is almost invariably the larger, the aggregate of them forming the great plexus to be separately considered.

5. Each nerve possesses its appropriate neurilema of dura mater.

It will not be forgotten, that, independent of the deep median fissures in the spinal cord, there are superficial lateral grooves on either side[3]: it is from these grooves, then, that the anterior and posterior fasciculi are found to arise. The course of the nerves within the spinal canal varies in different parts; in the cervical region their direction is nearly transverse; but the obliquity increases as we descend, and in the lumbar and sacral regions their course is nearly vertical. Within the canal.

OF THE CERVICAL NERVES GENERALLY.

The cervical nerves are eight in number; the

[2] The coexistence of the ganglion and the sensitive property of the nerve, does not *necessarily* imply a connexion; the sympathetic has ganglia, but probably does not transmit sensation.

[3] See Spinal Cord.

first pair passing out between the occiput and atlas, the eighth between the last cervical and first dorsal vertebræ.

Origin.

Origin. The first, sub-occipital, arises immediately below the junction of the medulla oblongata with the medulla spinalis; each root being formed by four or five fasciculi, and the posterior being somewhat smaller and a little inferior to the anterior: the spinal accessory nerve, which usually lies behind these roots, sometimes separates them and communicates with the posterior[1]. The *anterior* roots of the other cervical nerves consist of seven or eight filaments each: the posterior, which in these are much larger, are not so regular in the number of their filaments, there being usually three or four in the second, and as many as nine in the last cervical nerve. All these filaments unite, *immediately* after their origin, into bundles or fasciculi which subsequently combine to form their corresponding roots. The cervical nerves, after passing through the intervertebral foramina, divide into anterior and posterior branches.

Of the four superior Cervical nerves.

First cervical.

FIRST CERVICAL. (*Sub-occipital.*)

Situation. As it passes out of the spinal canal, between the occiput and atlas, this nerve lies in

1 The description of the origin of this nerve is given variously by different authors. Swan says, the posterior bundle

contact with, but beneath and behind the vertebral artery, between it and the first vertebra[2]: it then divides into two branches.

Anterior trunk. Smaller than the posterior, it runs forwards and outwards above the transverse process of the atlas, to the space between the rectus capitis anticus minor and lateralis muscles; then arching downwards anterior to the transverse process, it anastomoses with an ascending filament from the second cervical.—*Branches.* One to the vertebral artery, which divides into ascending and descending: a filament is given to each of the following muscles,—rectus capitis anticus major, minor, and lateralis.—*Communications*: with the superior cervical ganglion of the sympathetic, with the pneumogastric, the lingual motor, and the anterior branch of the second cervical nerves. Anterior.

Posterior trunk. This is larger but shorter. It takes its course backwards to the triangular Posterior.

frequently arises from the spinal accessory, and is smaller than the anterior. (Swan's Nerves, p. 60.) Bell describes the posterior as the larger root, both sometimes forming a union with the posterior roots of the second cervical. (Bell's Anatomy, vol. ii. p. 589.) Cloquet seems to imply that the most common origin is by one large root, anterior to the ligamentum dentatum; or where there are two roots, the anterior communicates with the spinal accessory. (Knox's Cloquet, p. 479.) This nerve is also frequently described under the name of "tenth cerebral."

[2] Its elongated ganglion will be found immediately behind the vertebral artery.

space bounded by the obliqui and rectus capitis posticus major muscles.—*Branches.* These are six or seven in number, distributed, internally, to the complexus and two posterior recti muscles; externally, to the obliquus capitis superior; inferiorly, to the obliquus capitis inferior.—*Communications.* With the posterior branch of the second cervical, behind the transverse process of the atlas.

Distribution.

SECOND CERVICAL NERVE.

Second cervical.

This nerve, immediately after its exit from the spinal canal, divides into its two trunks.

Anterior.

Anterior trunk. Smaller than the posterior: it passes forwards between the transverse processes of the atlas and axis.—*Branches.* One is given to the rectus capitis anticus major: the rest *communicate* with the first and third cervical nerves; with the superior cervical ganglion; with the pneumogastric, descendens lingualis, and spinal accessory nerves.

Posterior.

Posterior trunk. The largest in the cervical region: its course is backwards and upwards, between the complexus and obliquus capitis superior; it pierces the inner side of the former and becomes subcutaneous.—*Branches. Muscular,* to the levator anguli scapulæ, complexus, splenius, trachelo-mastoideus, trapezius, sterno-mastoideus, occipito-frontalis: *cutaneous,* to the scalp covering the occiput, even to the summit of the head.—

Communications. With the first and third cervical; with the supra-orbitar branch of the first division of the fifth; with the posterior auricular nerve, and cervical plexus.

THIRD CERVICAL NERVE.

Passing nearly transversely from its origin, through the intervertebral foramen between the second and third vertebræ of the neck, it divides into its two trunks. Third cervical.

Anterior trunk, passes forwards, covered by the splenius and levator anguli scapulæ.—*Branches. Muscular,* to the splenius, levator anguli scapulæ, rectus capitis anticus major.—*Communications*: with the superior and middle cervical ganglia; with the anterior branches of the second and fourth cervical nerves[1]. Anterior.

Posterior trunk. Smaller than the anterior; it winds downwards and backwards over the lateral articulation between the second and third vertebræ; it is then found between the complexus and semi-spinalis colli muscles; perforates the former as well as the splenius and trapezius, and terminates in the skin.—*Branches. Muscular,* to the Posterior.

[1] "This nerve continues to give sensibility to the lower part of the face, after the branches of the fifth are cut." (Bell's Anatomy, vol. ii. p. 591.) For the branches here alluded to, and the remaining communications of this trunk, see "*Cervical plexus.*"

above muscles, and the transversalis colli and multifidus spinæ[1].

FOURTH CERVICAL NERVE.

Fourth cervical. Appearing between the third and fourth vertebræ, this nerve divides like the last.

Anterior. *Anterior trunk.* Its course is outwards and forwards over the fourth vertebra.—*Branches*: to the scaleni muscles.—*Communications*: with the superior cervical ganglion; with the third and fifth cervical nerves, assisting in forming the plexus. This trunk forms the principal part of the phrenic[2].

Posterior. *Posterior trunk.* Smaller than those above, it takes its course backwards, passing between the semi-spinalis colli and complexus, and piercing the trapezius and splenius, it terminates in the skin.—*Branches*: to the above muscles; to the trachelo-mastoid and neighbouring mass. It *communicates* with the posterior trunk of the third cervical.

We now quit the individual description of the other cervical nerves, until the anterior branches

[1] Also, according to Cloquet, to the posterior recti and oblique muscles of the head. (Anatomy, p. 483.)

[2] The branches supplying the integuments of the neck and shoulder and the supra- and infra-spinati muscles, may be traced to the anterior trunk of the fourth nerve. "To these are attributed the false pains when the diaphragm is irritated: these too, in all probability, cause the convulsions of the shoulder when the diaphragm is wounded." (Bell's Anatomy, vol. ii. p. 591.)

of those already described, which form the cervical plexus, have been traced to their ultimate distribution.

CERVICAL PLEXUS.

This plexus, though subject to variety in the mode in which the different branches unite to form it, is pretty uniform in its distribution. The anterior trunks of the first four cervical nerves having each communicated, as already noticed, by a filament, with the superior cervical ganglion of the sympathetic, form arches by anastomosing each with the trunk above and below it, the first nervous loop surrounding the transverse process of the atlas. From the convexity of these arches branches arise, which soon reunite more externally, and interlace one with another. It is this interlacement which forms the plexus. Formation of plexus.

To display the cervical plexus, the platisma myoides should be carefully divided along the margin of the clavicle, and reflected from below upwards: the trapezius may be then pressed outwards, and the cervical fascia dissected from the sterno-mastoid muscle. The student will call to mind the situation and boundaries of the triangles of the neck, and he will then observe that this plexus is situated in the posterior superior triangle, the sides of which are formed, posteriorly by the trapezius, anteriorly by the sterno-mastoid, and by the omo-hyoid muscle inferiorly. Dissection.

Position. The cervical plexus extends from the transverse process of the second to the inferior border of the fourth vertebra of the neck. It is covered by the posterior border of the sterno-cleido-mastoid muscle, and lies first on the scalenus posticus, but more externally, on the levator anguli scapulæ: on its inner side are found the carotid artery, internal jugular vein, and pneumogastric nerves. In making the dissection, it will be found entangled with small blood-vessels and the deep lymphatic vessels and glands of the neck, all held together by cellular tissue. Having gained a general idea of the position of the plexus, the student may now carefully divide the sterno-mastoid muscle, but in such a way that it may be replaced at pleasure, for the purpose of studying more in detail the relative anatomy of the parts.

Branches. The *branches* of the cervical plexus are divided into *superficial* and *deep*: the former being subdivided into *ascending* and *descending*; the latter into *anterior* and *descending*.

- Cervical Plexus.
  - Superficial.
    - Ascending.
      - Auricularis magnus.
      - Superficialis colli.
      - Mastoid.
    - Descending.
      - Acromial.
      - Supra-clavicular.
  - Deep.
    - Anterior.
      - Muscular.
      - Communicating.
    - Descending.
      - Subclavicular.
      - Phrenic.

SUPERFICIAL BRANCHES.

Ascending: three in number; middle, anterior, posterior. They lie beneath the platisma and cervical fascia.

Auricularis magnus[1], the middle and largest of these three branches, passes outwards, and turning round the posterior border of the sterno-mastoid muscle, ascends between it and the superficial layer of the cervical fascia to the space between the angle of the jaw and lobe of the ear, accompanying, in most instances, the external jugular vein[2]. It divides into two sets of branches. The *deep* filaments, two or three in number, pass into the substance of the parotid gland, supplying it, and anastomosing with the facial division of the seventh. The *superficial* filaments, which are more numerous and larger, are distributed in anterior and posterior branches to the integuments of the external ear and neighbouring part of the head; *communicating* with the superficial temporal and posterior aural branches of the facial. Auricular.

Remark. This nerve may be divided in opening the external jugular vein: a loss of sensation in the skin to which it is distributed would ensue. It gives no muscular branches. Remark.

Superficialis colli: not so large as the last, by Superficialis colli.

[1] Called by some, "superficialis colli."

[2] This vein occasionally passes to the inner border of the sterno-mastoid muscle, there joining either the internal jugular or innominata.

a branch of which its place is sometimes supplied: it passes upwards and forwards to the submaxillary gland. This nerve gives branches in its course, to the platisma and digastric muscles and the skin; and terminates by being distributed to the submaxillary gland. Its *communications* are, superficially in its course upwards, with the cervico-facial division of the seventh nerve; and in the gland, with the chorda tympani and mylo-hyoidean branch of the inferior maxillary nerve.

Mastoid. *Mastoid*, is found passing up along the posterior border of the sterno-mastoid muscle, and lying, in its course, on the splenius: it is distributed to the skin of the lateral and posterior occipital regions and ear. It *communicates* with the large posterior trunk of the second cervical, the posterior aural branch of the facial, and the auricularis magnus nerve.

Descending: these are acromial and supra-clavicular. They are found taking their course downwards, in the interval between the trapezius and sterno-mastoid muscles.

Acromial. The *acromial* branches distribute filaments to the trapezius, and then terminate in the deltoid and neighbouring integument.

Clavicular. The *supra-clavicular* branches consist of several long filaments, which, after descending under cover of the platisma, pass over the centre of the clavicle[1] and clavicular origin of the sterno-mas-

[1] Occasionally a filament may be seen perforating the clavicle.

toid muscle, and are subsequently found between the skin and pectoralis major: to these parts and to the mamma they are distributed, anastomosing with the acromial branches. Some may occasionally be traced for a considerable distance down the arm.

DEEP BRANCHES.

Anterior consist of *muscular* and *communicating*. The latter descends, and inclining inwards beneath the sterno-mastoid muscle, anastomoses with the descendens lingualis: this communication forms a small triangular plexus, usually opposite the intersection of the sterno-mastoid and omo-hyoid muscles, and a loop or arch thus results, which may be seen when the former muscle is raised. From this plexus and from the convexity of the arch, the *muscular* branches arise: they consist of three or four long filaments which are distributed to the sterno-hyoid, sterno-thyroid, and omo-hyoid muscles. **Loop and plexus.**

Descending: these are subclavicular and phrenic. The *subclavicular* branches descend in the posterior triangular space, and passing through a quantity of cellular tissue behind the clavicle, terminate in the axilla. In their course they distribute filaments to the upper part of the subscapular and posterior belly of the omo-hyoid muscles. The longest and largest of these branches is that distributed to the serratus magnus muscle, **External respiratory.**

named by Bell the *external respiratory* and counterpart of the phrenic. This nerve is derived principally from the fourth and fifth cervical, being usually connected with the phrenic: it descends behind the scaleni and axillary vessels and nerves, on the surface of the serratus magnus, to which muscle it is exclusively distributed[1].

Phrenic.

Phrenic or *diaphragmatic* nerve. This nerve is first *formed* by two filaments which may be traced to the anterior trunks of the third and fourth cervical: these, of which the latter is by far the larger, unite on the anterior scalenus muscle, and the resulting trunk soon receives a reinforcement from the anterior division of the fifth cervical as it passes to join the brachial plexus, and likewise a filament from the middle or inferior cervical ganglion[2]. First of all the phrenic nerve is placed between the rectus capitis anticus major and scalenus anticus muscles; it then bends over

How formed.

Course.

[1] "This muscle has other nerves coming from the spinal marrow, because it has to combine the motions of the frame in locomotion. But the long descending nerve is a respiratory nerve, which we may know from its origin, course, and destination: in its origin and course it is like the diaphragmatic nerve, and in its destination also, since it is given to a muscle necessary to full inspiration."—*Bell's Anatomy*, vol. ii. p. 554.

[2] The brachial branches occasionally do not join this nerve till it passes into the thorax. Cloquet remarks, "that sometimes the volume of the phrenic is augmented by a twig of the descending branch of the hypoglossal nerve, or of the plexus which terminates it, and by a filament of the superior cervical ganglion." The former of these is not very rare. Sir Charles Bell traces this nerve to his respiratory track.

the internal margin of the latter, and descends on its anterior surface to the anterior mediastinum[3]. In this course it crosses the subclavian vessels at right angles, passing between them, and having therefore the vein anteriorly, and the artery posteriorly. Here also it winds round the internal mammary artery, from its outer to its inner side; and then passing anterior to the root of the lung, it subsequently descends between the pericardium and adherent pleura to the diaphragm.

The two nerves are not precisely similar in their course and distribution. The *right* nerve takes a straighter course, and is situated on a plane *anterior* to the left: it is also found attached to the outer and back part of the vena cava descendens, till that vessel enters the pericardium. The *left* nerve is *posterior*, and having to wind round that portion of the pericardium which covers the apex of the heart, is the *longer* trunk.

In its course the phrenic gives small filaments Distribution. to the anterior scalenus muscle and remains of the thymus gland[4]; but the principal part of *both* these nerves is distributed to the diaphragm both on its convex and concave surface. They *both* send filaments which perforate the diaphragm to

[3] I have seen the transverse humeral artery separate this nerve from the scalenus: and in this part of its course the nerve frequently deviates more or less from the median line.

[4] I have not been able to trace filaments to the pericardium, but they are described by some authors.

communicate with the cœliac plexus and gastric branches of the par vagum; those of the *right* trunk, passing the opening for the vena cava, also send branches of communication to the hepatic plexus; whilst those of the left pass around the œsophagus, communicating with the opposite nerve and distributing filaments to the renal capsule and crura of the diaphragm[1].

Remarks on function, &c.

Remarks. The phrenics are the muscular nerves of ordinary respiration, and their existence, in an unimpaired condition, is essential to life. Thus, compression of the spinal marrow above their origin is instantly fatal. The precise cause of this is an interesting inquiry. It is evident that by the above-mentioned lesion all the *voluntary* nerves below the seat of injury become paralysed: these, however, under any condition are incapable of carrying on respiration, unaided by the phrenics; or, in other words, the action of the diaphragm is indispensable to the performance of this function. Moreover, the brain may be removed, and respiration still proceed; therefore the phrenic nerves are not dependent on this source of *voluntary* power. The explanation must be that the injury is done to that portion of the *true spinal marrow* connected with respiration; and that, in consequence of the commu-

[1] Cloquet observes that it is not uncommon to see the terminating twigs of the phrenics presenting more or less numerous enlargements resembling ganglia.

nicating medium between the excitor and motor nerves of this system being destroyed, the phrenic nerves no longer receive their wonted reflected impression.

The relative position of this nerve and the subclavian vessels should be studied. In the *external* operation for placing a ligature round the subclavian artery, where the outer margin of the anterior scalenus muscle is the guide, there can be little or no fear of injuring the nerve; but in the internal operation, or in dividing the muscle, it is in much more danger. The communications between this nerve, at its origin with a branch distributed to the scapular muscles, and at its termination with the gastric and hepatic nerves, accounts, probably, for the aching shoulder in disordered stomach and liver; and for hiccough arising from the presence of acid in the stomach, &c. Practical remarks.

OF THE FOUR INFERIOR CERVICAL NERVES.

These are larger than the four superior nerves. The first of them passes out of the intervertebral foramen between the fourth and fifth cervical, the last between the seventh cervical and first dorsal vertebræ. Each nerve, as it leaves the spinal canal, divides in the same manner as the four superior nerves into an anterior and posterior trunk. Exit.

FIFTH CERVICAL NERVE.

Fifth cervical.

Anterior trunk. Its *course* is forwards and outwards, towards the scaleni muscles.

Branches. Filaments are distributed to the longus colli, scaleni, and levator scapulæ muscles; others, as before noticed[1], assist the fourth in supplying the serratus magnus; and it communicates with one of the cervical ganglia, with the phrenic, and with the sixth cervical nerves. The main trunk then emerges from between the anterior and middle scaleni muscles[2], and joins the sixth in assisting to form the axillary plexus.

Posterior.

Posterior trunk. This, in its *course* and *distribution*, is similar to the posterior trunk of the fourth cervical, viz. passing backwards between the complexus and semi-spinalis muscles, piercing the splenius and trapezius, and being distributed to them and the integuments of the neck.

SIXTH CERVICAL NERVE.

Sixth cervical.

Anterior trunk passes towards the scaleni muscles. Its muscular *branches* are considerable, viz. short filaments to the longus colli and scalenus anticus; longer and larger ones descend to

[1] See "External Respiratory Nerve."

[2] The middle and posterior scaleni are described by many as one double-headed muscle; not infrequently, however, two or three branches of the brachial plexus separate these heads.

the levator scapulæ, serratus magnus, and latissimus dorsi muscles. It *communicates* by filaments with the sympathetic, the fifth and seventh cervical nerves, and frequently the phrenic. The continued trunk then inclines outwards and downwards between the anterior and middle scaleni to join the fifth and seventh nerves in the axillary plexus.

Posterior trunk passes backwards with those of the fourth and fifth, between the complexus and semi-spinalis colli, to which muscles it is distributed. Posterior.

SEVENTH CERVICAL NERVE.

Anterior trunk. Small *filaments* are occasionally sent beneath the clavicle to the pectoral muscles. It *communicates* regularly with the inferior cervical ganglion[3]. Nearly the whole nerve then joins the sixth in the axillary plexus. Seventh cervical.

Posterior trunk has a similar course and distribution to that of the sixth.

EIGHTH CERVICAL NERVE.

Anterior trunk. It sends *muscular filaments* in conjunction with the last; and after *communicating* with the inferior cervical ganglion it joins Eighth cervical.

[3] "These communications betwixt the cervical nerves and the sympathetic nerve are, I believe, branches of the sympathetic running down upon the arms."—*Bell's Anatomy*, vol. ii. p. 593.

a branch from the first dorsal, in the lower part of the plexus: its *course* is between the scaleni muscles, immediately above the subclavian artery.

Posterior trunk. Course and distribution like the last.

AXILLA.

It may be well, previous to proceeding with the description of the brachial plexus of nerves, that the student should be reminded of the boundaries and general contents of the axilla. This space is conical, its *base* being formed by the integuments, and a somewhat dense fascia stretching between the pectoralis major and latissimus dorsi muscles; when this is divided its other boundaries are exposed. The *apex* of the cone is at the coracoid process of the scapula. It is further bounded, *anteriorly*, by the two pectoral muscles: *posteriorly*, by the latissimus dorsi and serratus magnus; *externally*, by the outer edge of the scapula and the subscapular muscle; *internally*, by the upper ribs, superior digitations of the serratus magnus, and intercostal muscles. Besides the nerves, this space contains the axillary artery and vein, which are relatively giving off and receiving, externally, the subscapular and circumflex branches, and internally the thoracic branches. All these parts lie imbedded in cellular membrane (which is often infiltrated with serum), and surrounded by numerous glands, connected to the vessels by

Description of axilla.

their nutrient branches, and continuous beneath the clavicle with the cervical glands.

AXILLARY PLEXUS OF NERVES.

The name of *axillary* or *brachial plexus* is applied to the interlacement formed by the union of nearly the whole of the *anterior* trunks of the *four inferior* cervical and *first* dorsal nerves. It will be observed that, in passing to form this plexus, the nervous trunks are collected into three cords; the superior, descending, consists of the fifth and sixth cervical; the middle, still inclining downwards, of the seventh alone; the inferior, nearly horizontal, is composed of the last cervical and first dorsal nerves: the union of these into one takes place opposite the first rib. Axillary plexus. How formed.

The *situation* of the plexus is on the lateral and inferior part of the neck, and in the axilla. It *extends* from between the scaleni muscles to a point opposite the coracoid process of the scapula, or, in other words, the apex of the axilla[1]. In its *course*, it first lies between the scalenus anticus and medius muscles, superior and on a plane posterior to the subclavian artery[2]: it then emerges from its muscular connexions, though still immersed in cellular tissue, and passes to- Position. Course.

[1] It may be remarked that, according to many anatomical descriptions, these nerves retain the title of 'plexus' even after the ultimate division into distinct branches.

[2] A portion of the plexus is also occasionally separated from the artery by the interposition of the scalenus medius muscle.

wards the subclavicular space, then lying between the muscle of that name and the first rib ; and immediately after, as it enters the axilla, it is found lying upon the first digitation of the serratus magnus. Here the plexus, which was inclining to the posterior part of the vessels as it descended, now gives off its ultimate diverging branches; these surround the artery and separate it from the vein, which latter is excluded and continues to lie superficially[1].

In the *first* division of its passage, then, the plexus is found in the posterior inferior triangle of the neck; secondly, in the subclavicular region ; and *thirdly*, in the upper part of the axilla.

Practical points.

Remarks. Throughout its whole course, but especially in the subclavicular region, the relative position of the axillary plexus should be studied with great care by the surgical anatomist. The proximity of the vessels and nerves will indicate the cause of paralysis, numbness, pain, or perhaps loss of sensation in the parts to which these nerves are distributed, in cases of pressure from aneurismal enlargement of the subclavian artery, innominata, or even aorta. It will be evident that it is not only the vessels, but these nerves also, which must be avoided in the dangerous experiment of extirpating tumours from the clavicu-

[1] The relative position of these parts as they pass through the axillary space will be considered under the head of the *Brachial branches*.

lar region, behind the sterno-mastoid muscle[2]. In the subclavicular region these nerves are obnoxious to injury, from their proximity to the artery in the operation of tying the subclavian trunk; and the mistake of including one of the nervous cords in the ligature, in place of the artery, is an accident to which the most skilful surgeons are liable[3]; for it is a matter of considerable difficulty, in a deep wound, to distinguish accurately by the touch a large nerve from an artery. The pulsation of the vessel is a guide, but by no means an unerring one; indeed the only indication to be depended on is the cessation of throbbing in the aneurismal sac when pressure is made on the artery with the finger. This last precaution, previous to tightening the ligature, is particularly insisted upon by Mr. Hodgson, to prevent the possibility of including one of the brachial nerves[4].

[2] See Allan Burns's Anatomy of the Head and Neck, pp. 60 and 64.

[3] This accident occurred to Mr. Liston, in the first successful case of ligature on the subclavian artery in Great Britain. The ligature had been passed beneath one of the nerves, but the error detected by the necessary precaution mentioned in the text. (Edin. Med. and Surg. Journal, No. 64.) I witnessed a similar case, which was remedied with the same promptitude and dexterity. Should the operator be so unfortunate as to tighten the ligature around a nerve, the mistake is soon discovered by the pain evinced at the time, and the subsequent numbness, &c. Such momentary pressure is not, however, *necessarily* followed by dangerous or even unpleasant consequences.

[4] See Hodgson on Diseases of Arteries, p. 362.

The difficulty of distinguishing and selecting the artery is frequently much augmented by the comparatively feeble pulsation of this vessel, and the anxiety of the operator to avoid the subclavian vein, which, it will be remembered, is on the opposite side of the artery, that is, anterior and inferior to it.

Temporary paralysis may be produced by accident to the sternum or clavicle, either from displaced bone, or effusion of blood from a torn vessel[1]. Deep-seated abscess may produce the same result. Lastly, the pain in dislocation of the head of the humerus into the axilla is referable to pressure and tension of these nerves.

- Axillary Plexus.
  - Thoracic.
    - Muscular.
    - Cutaneous.
    - Mammary.
  - Scapular.
    - Supra-scapular.
    - Sub-scapular.
  - Brachial.
    - Auricular. — Circumflex.
    - Cutaneous.
      - Internal cutaneous.
      - Small internal cutaneous.
      - External cutaneous.
    - Muscular.
      - Median.
      - Radial.
      - Ulnar.

BRANCHES OF THE AXILLARY PLEXUS.

The branches of the axillary plexus may be classed under three heads: Thoracic, Scapular, Brachial.

[1] I lately witnessed a case of this sort in St. Thomas's Hospital.

THORACIC NERVES.

These nerves, which are usually two in number, descend in front of the axillary vessels, and communicating with the second intercostal nerve, divide into filaments which are distributed to the pectorales major and minor muscles: some may be traced till they terminate in the pectoral integument and mamma. Thoracic.

The thoracic nerves are *derived* from the inferior part of the plexus, and may be principally traced to the seventh cervical, although frequently connected with filaments which pass behind the subclavian artery, from the inferior of the three cords[2].

SCAPULAR NERVES.

These consist of supra-scapular and sub-scapular: the largest portion of each accompanies the corresponding artery of the same name.

Supra-scapular. This nerve takes its *course* downwards and backwards, from the superior and posterior part of the plexus to the root of the coracoid process of the scapula. It then passes beneath the ligament which converts the notch of the superior costa into a foramen, whilst the Supra-scapular.

[2] These nerves are sometimes included under the head of *anterior* thoracic; the external respiratory is then classed as a *posterior* thoracic branch. This last-mentioned nerve belongs equally to the axillary and cervical plexus, it being derived from the fourth and fifth cervical trunks. The description of it will be found under the *subclavicular* division of the *cervical* plexus.

supra-scapular artery usually passes above the ligament; the reverse, however, is sometimes the case: the nerve then traverses the great notch at the root of the acromion, and terminates in the infra-spinous fossa. Previously to passing the coracoid notch, this nerve gives off its *subscapular* branch. In the supra-spinous fossa it lies beneath the muscle of that name, and gives filaments to it. In the infra-spinous fossa its terminating filaments are distributed to the infra-spinatus and teres minor muscles.

The supra-scapular nerve may be *traced* back to the fifth cervical trunk, and is connected with the circumflex nerve.

Sub-scapular.

Sub-scapular. These are irregular, consisting of that already noticed as derived from the last-described nerve, and one or two more which are usually given off from the plexus in common with the circumflex nerve. They are distributed, in company with the branches of the subscapular artery, to the subscapular and teretes muscles.

BRACHIAL NERVES.

This division of the branches of the axillary plexus is by far the largest. It consists of, 1. circumflex; 2. internal cutaneous; 3. internal small cutaneous; 4. external cutaneous; 5. ulnar; 6. median; 7. radial.

Before proceeding to the individual description, it will be right to notice the relative connexions of the vessels and nerves throughout the axillary space, in order to make such practical deductions as may be useful.

As the axillary artery descends obliquely through the axilla, it lies above on the thoracic, below on the humeral side of this region; whilst its central portion is opposite the glenoidal articulation. It is here that the artery becomes first enveloped by the brachial nerves, and in its inferior third it is completely surrounded by them. Their relation in this part of the course of the axillary artery is exposed by turning aside the vein. Relative anatomy in axilla.

The forked origin of the median nerve leaves the anterior surface of the artery exposed below. On the *outer* side of this vessel, then, we find the external head of the median and the external cutaneous nerves, united above but separate below; on the *inner* side, the internal head of the median, the ulnar, and the internal cutaneous nerves, also connected above; posteriorly, are the radial and circumflex branches. Previous to leaving the axilla, the median and internal cutaneous nerves are sometimes lying superficial to the artery[1].

[1] It may be well to notice, that the *external cutaneous* is sometimes also called *musculo-cutaneous*, and *perforans Casserii*: the *radial* is also known as *musculo-spiral*: the *median* has for its synonymes, *brachial*, and sometimes *radial*: the *circumflex* is also named *articular*, and *axillary*: and the *ulnar* and *cubital* are the same. It may be added, that the *internal small cutaneous* is frequently described with the nerves of Wrisberg. The names used in the text will not be varied.

Remarks. *Remarks.* A knowledge of the relative anatomy of these parts will indicate the difficulties of placing a ligature upon the axillary artery; and the close connexion of the nerves to this vessel explains the cause of the excessive pain and loss of power in the arm in cases of axillary aneurism[1].

CIRCUMFLEX NERVE.

Circumflex. This branch passes from the upper and back part of the plexus, in an oblique direction downwards and outwards, to join the posterior circumflex artery anterior to the subscapular muscle. The vessel and nerve leave the axilla together, by an opening which is bounded above by the capsular ligament, below by the tendons of the teres major and latissimus dorsi, anteriorly by the humerus, posteriorly by the long head of the triceps. They are then found encircling the neck of the bone, beneath the deltoid.

Branches. The first *filaments* of the nerve are distributed to the teres minor muscle. On leaving the axilla, it divides into a superior and descending set; by the *former* the infra-spinatus muscle and capsule of the joint are supplied, as well as the upper part of the deltoid; and some filaments become cutaneous on the back of the arm. The *descending*

[1] Mr. Lawrence mentions two instances in which these symptoms were remarkably evident, rendering perfectly useless the arm and hand. (Med. Gaz., vol. vi. p. 649.)

branches are entirely distributed to the deltoid, and may be traced down even to its insertion.

The circumflex nerve is *derived* principally from the superior of the three cords, but is intimately connected with the supra-scapular and radial nerves.

INTERNAL CUTANEOUS NERVE.

This nerve appears to be derived from the ulnar at its root. Emerging from the axillary cellular tissue, it descends beneath the fascial aponeurosis of the upper arm on its inner side, in company with the basilic vein, to the internal condyle of the humerus, at, or a short distance above which, it divides into its terminating branches. Internal cutaneous.

Connexions. In its descent, this nerve first lies between the median and ulnar, but soon becomes superficial. Its position relative to the basilic vein is variable; being, in different cases, anterior, posterior, or on either side of this vessel: occasionally the nerve and vein are a little removed from each other, and in some instances they cross.

Branches. A few small filaments are given off above its division, which descend and are distributed to the skin. Its terminating branches are external and internal. Branches.

The *external* or smaller branch passes downwards and outwards, guided by the inner margin of the biceps: it soon pierces the brachial aponeu- External.

rosis, and is found usually crossing over or under the median basilic vein, being here superficial but parallel to the median nerve. It descends between the integument and fascia of the fore-arm, and in this course distributes filaments both on its ulnar and radial side; and terminates in the skin covering the anterior annular ligament of the carpus.

Internal. The *internal* branch is the larger of the two: it pierces the fascia covering the brachialis anticus muscle, and then gives filaments to the skin around the elbow-joint. It descends on the fore-arm, still in company with the basilic vein, and therefore appears as a continuation of the trunk of the internal cutaneous nerve: in this descent it continues to give filaments, similar to the external branch, on either side; some of the largest pass round the border of the ulna, and are lost in the skin on the back of the arm; its terminating filaments may be traced to the integument on the inner and back part of the hand.

Communications. On the fore-arm there is a free anastomosis between filaments given off from either branch of this nerve, with each other, and with the external cutaneous nerve on the radial side. The termination of the nerve communicates with the dorsal branch of the ulnar.

The internal cutaneous nerve may be *traced* back to the inferior of the three cords.

Remarks. In placing a ligature on the brachial artery, this nerve will be found lying with the ulnar on its inner side. The external branch, when it passes over the median basilic vein, is liable to puncture in bleeding in this situation: very distressing symptoms may follow this apparently trifling injury.

SMALL INTERNAL CUTANEOUS NERVE[1].

Small cutaneous, or Wrisberg's.

This nerve may be usually found arising separately or in conjunction with the last, from the inferior brachial cord; sometimes it is only a branch of the large internal cutaneous: it, however, always receives a considerable reinforcement by junction with Wrisberg's nerves, which are piercing the external intercostal muscles of the second and third spaces, opposite the anterior margin of the serratus magnus. From this communication two or three filaments are given to the axillary cellular tissue and skin: the largest branch, which is principally the superior nerve of Wrisberg, descends even to the inner condyle, supplying in its passage the integument on the inner part of the arm. (See *Dorsal nerves.*)

[1] This nerve, which is *principally* formed by the external branches of the second and third intercostal nerves and descends under the name of 'the nerves of Wrisberg,' nevertheless finds a more appropriate place under the head of Brachial cutaneous nerves. For the description of their origin, see '*Dorsal—second and third.*'

EXTERNAL CUTANEOUS NERVE.

External cutaneous.

This nerve is larger than the internal cutaneous, and passes from the upper and middle division of the plexus, being connected first of all with the outer head of the median. It leaves the plexus and passes downwards and outwards to the coraco-brachialis muscle; and having reached its posterior border, it pierces the muscular fibres about the central part of their course[1], and is then found descending between the biceps and brachialis anticus to the elbow-joint, opposite which and to the outer side of the tendon of the biceps, it pierces the fascia and becomes subcutaneous. It immediately passes beneath the median cephalic vein, and continuing its descent on the radial side of the fore-arm, it terminates above the wrist, by dividing into anterior and posterior branches[2].

Branches.

Branches. One long filament to the coraco-brachialis muscle, whilst the nerve is piercing it. Next, a considerable branch to the biceps, and another to the brachialis anticus. One or two filaments, usually derived from one of the muscular branches, descend in company with the brachial artery. At the bend of the elbow, two or three filaments are given to the skin of the

[1] Sometimes, though comparatively rarely, this nerve passes behind the coraco-brachialis muscle.

[2] Sometimes this division takes place high up in the arm.

anterior and outer part of the fore-arm; and as it descends others are separated which have a similar destination. The *terminating* branches are lost in the integument of the ball and back of the thumb, and second metacarpal bone.

Communications. In the upper arm, with the median, and rarely in this part of its course with the inner cutaneous. In the fore-arm, with the cutaneous branch of the radial, and the external division of the inner cutaneous nerve. At the wrist, the *posterior* terminating branch communicates with a similar branch of the radial; and the *anterior* terminating branch, with the superficial palmar branch of the median. **Communications.**

The external cutaneous nerve may be traced to the superior cord; and communicates with the middle, through the medium of its connexion with the ulnar.

Remarks. It will be observed that this nerve has muscular connexions, and gives muscular branches above the elbow, below which point it is greatly diminished in size and is solely cutaneous; whence its appropriate name of '*musculo-cutaneous nerve.*' **Remarks.**

The branch crossing the median cephalic at the elbow-joint is usually posterior to this vein, and therefore not liable to be wounded in bleeding: this is a reason for selecting the median cephalic for venesection, in addition to the far more weighty one of avoiding injury to the brachial artery. In tying the axillary artery, the trunk of this nerve will be found with the outer head of the median, on its external side.

ULNAR NERVE.

Ulnar.

Larger than the last, but smaller than the median, this nerve descends from the lowest part of the plexus, and quitting its connexion to the internal cutaneous nerve, it lies between the opposed margins of the biceps and triceps muscles, being bound to the latter by a strong intermuscular septum of fascia. It inclines backwards to the posterior part of the inner condyle of the humerus, and in this course is accompanied by the inferior profunda artery. At the elbow-joint, it lies in the groove between the inner condyle and olechranon, where it separates the two heads of the flexor carpi ulnaris which are attached to these processes of bone. It then descends, inclining forwards, and is situated in its course down the anterior and inner part of the fore-arm upon the flexor digitorum profundus, and covered by the flexor carpi ulnaris. It accompanies the ulnar artery, lying to its ulnar side. Passing to the carpus, where it is protected by the flexor carpi ulnaris tendon and the strong fascia attached to its radial border, it crosses anterior to the annular ligament and on the outer side of the pisiform bone, where it is usually bound down by a ligamentous process connecting these two parts. On, or above the annular ligament, this nerve divides into its terminating branches.

Branches. In the inferior third of its course through the upper arm, some filaments are given to the triceps, and a few are distributed to the skin covering this muscle. In the upper part of the fore-arm, it gives filaments to be distributed to the flexor carpi ulnaris and flexor profundus muscles: and another, after running on the ulnar artery for some time, terminates in the flexor sublimis and neighbouring skin. The large *dorsal* branch is usually given off about the middle of the fore-arm, and winding round the ulna, beneath the flexor carpi ulnaris tendon, it descends on the extensor carpi ulnaris to the back of the hand, where it divides into filaments which lie between the extensor tendons and cutaneous veins, and are distributed in the following order: two or three filaments to the skin; one, the *inner dorsal* filament, runs along the ulnar border of the little finger, and is lost in the abductor minimi digiti and integument; another, the *outer dorsal* filament, passes between the opposed surfaces of the ring and little finger, to the skin of which and of the middle finger it is distributed. The terminating branches of the ulnar nerve are superficial and deep. Branches. Dorsal.

The *superficial* branch is the larger; it passes forwards on the border of the abductor minimi digiti, and divides into two filaments; one is partly Superficial.

distributed to the muscles on the inner side of the palm, and then passing along the ulnar side of the little finger, terminates on the last phalanx: the other inclines outwards, and sending a filament to the last lumbricalis muscle, divides into two branches, which are distributed to the opposed sides of the little and ring fingers.

Deep. The *deep* branch quitting the superficial, passes beneath the abductor minimi digiti, to which and the flexor brevis it gives filaments: it then crosses the metacarpus, forming an arch, the convexity of which is towards the phalanges: in this course it is covered by the flexor tendons and lumbricales, and lies upon the interossei muscles, to which it distributes filaments, and then terminates in the abductor indicis and adductor pollicis. This branch accompanies the deep palmar arch of arteries; and usually dips down between the abductor and flexor brevis minimi digiti, together with the deep communicating branch of the ulnar artery, to gain the deep palmar region.

Communications. *Communications.* In the fore-arm, with the internal cutaneous nerve, by its *superficial* filament: opposite the cleft between the ring and little fingers, and on the former by its *superficial terminating* branch, with the median; also by the *deep* palmar branch, with the median: by the *dorsal* branch, with the dorsal of the radial. The palmar and dorsal branches communicate with each other between the fingers.

The ulnar nerve may be *traced* to the inferior brachial cord.

Remarks. In the operation of tying the brachial artery, the ulnar nerve will be found on its inner side; in close apposition above, but separated by the intermuscular ligament below, where the nerve is found inclining backwards. Now, this nerve, whilst lying on the edge of the triceps, is accompanied by the inferior profunda artery which is on its radial side. The median nerve and brachial artery hold the same relative position, and this similitude might lead an operator, who was searching for the arterial trunk, to take up the branch, especially where the latter was enlarged from anormal action: "For," says Dr. Harrison, "though in the dissected arm, the inferior profunda artery appears at some distance from the brachial, if the parts be pressed as nearly as possible into their natural relations, those vessels will be found close to each other." The tendon of the biceps ought, however, to be sufficient guide. Remarks.

The ulnar nerve and artery of the same name do not become attached till the middle third of the fore-arm is reached, below which the nerve is to the inner side of the vessels; this should be remembered in passing a ligature round the artery. The course of this nerve behind the inner condyle will explain the tingling sensation felt in the last two fingers, when that process of bone is struck. Lastly, the superficial position of the nerve at the wrist renders it liable to division from incised wound; in which case, it should not be forgotten that nerves reunite after such injury, and that after cleansing the wound and paying the proper attention to the artery, the adhesive process should be brought about as soon as possible. Laceration of the digital branches of the ulnar nerve is a not uncommon cause of tetanus[1].

MEDIAN NERVE.

Median. This nerve is usually of nearly equal size with the radial. Its two roots, after becoming disengaged from the plexus, are found placed, one on either side of the brachial artery; the external still connected to the outer cutaneous, and the internal to the ulnar nerve. These heads converge and unite anterior to the artery, and the nerve then accompanies this vessel down the arm, lying first upon it, and gradually inclining to its ulnar side as they together approach the elbow.

Course. In its course through the upper arm, the median nerve is only covered by the integument and strong brachial aponeurosis; and both it and the artery are tending from the inner to the anterior

[1] Dupuytren mentions the case of a man who died of tetanus, and in whom the only mark of a previous injury was a small cicatrix in the arm. On dissection a portion of *whip* was found imbedded in the ulnar nerve.

surface of the humerus. In the inferior third of the upper arm, where the nerve lies to the ulnar side of the artery, it rests upon the brachialis anticus muscle, and is separated from the ulnar nerve by the strong tendinous septum which is descending from the insertion of the coraco-brachialis to the inner condyle. At the elbow-joint, the nerve continues on the ulnar side of the artery, the latter being between the former and the biceps tendon. It then dips down between the supinator longus and pronator radii teres, and quitting the brachial vessels, passes between the humeral and ulnar origins of the latter muscle to gain the situation it occupies through the whole fore-arm, namely, between the flexor digitorum sublimis and profundus. It is thus hidden until it arrives near the carpus, a short distance above which it comes into view, lying between the outer tendon of the flexor sublimis and the flexor carpi radialis: in company with these tendons it passes beneath the annular ligament to the palm of the hand, where it divides into its five digital branches.

Branches. In the upper arm, the median nerve rarely gives off any branches. In its passage across the elbow-joint and in the fore-arm its muscular filaments are separated, which are distributed to nearly all the flexors and pronators indiscriminately. The *interosseous* branch passes backwards to the interosseal space, accompany-

Branches.

Anterior interosseous.

ing the artery of the same name along the anterior surface of the interosseous ligament, and under cover of the flexor pollicis and flexor profundus: to these muscles and to the flexor sublimis, filaments are given: at the upper border of the pronator quadratus, this branch, after supplying the last-named muscle, pierces the interosseous ligament with the accompanying artery, and terminates in a lash of cutaneous filaments on the back of the hand. The *cutaneous* palmar branch is given off from the median a little above the wrist: it passes superficial to the annular ligament and palmar fascia, and is distributed to the skin of the palm.

Digital. The *digital* branches are five in number. The *first* is principally distributed to the muscles of the thumb, along the radial border of which its continuation extends to the last phalanx: this branch crosses the adductor and flexor brevis pollicis. The *second* digital branch separates from the first, and crossing the metacarpal bone of the thumb, runs along its ulnar border: this branch assists in supplying the flexor brevis pollicis. The *third* digital branch crosses the first lumbricalis muscle, to which it gives a filament, and then proceeds along the radial side of the index finger, frequently supplying a filament, with the last described, to the thumb. The *fourth* digital branch proceeds in the second interosseal space to the bases of the first phalanges; it here divides into two filaments, which are sent along the opposed margins of the index and middle fingers: this branch is the largest of the five, and usually supplies the second lumbricalis muscle. The *fifth* digital branch in like manner supplies the third lumbricalis, and runs along the opposed borders of the middle and ring fingers.

The nervous palmar arch is situated posterior to the arterial; each branch being accompanied by a corresponding artery which perforates it. The mode in which the digital branches terminate, is by a deep filament to the root of the nail, and by a lash of filaments to the skin of the finger-tips. Palmar arch.

Communications. The median nerve frequently communicates with the ulnar by a branch sent on the ulnar artery. By its *superficial palmar* branch, with the anterior terminating branch of the external cutaneous, and with the radial. By the *second digital* branch, usually, with the deep palmar branch of the ulnar: by *each digital* branch, with the terminating filaments of the radial, between the fingers: by the *fifth digital* branch, at the base and on the last phalanx of the ring finger, with the ulnar. The digital branches communicate with *each other* on the last phalanges. Communications.

The superior *origin* of the median nerve may be traced to the upper and middle cords; whilst the inferior is derived from the lowest cord.

Remarks. The connexion of the median nerve Remarks.

N 2

with the brachial artery throughout the upper arm, and the not infrequent variation of their relative positions, should not be forgotten in the operation of tying this vessel. Where the median *basilic* vein is selected for venesection, it is possible that the median nerve may be wounded by the point of the lancet; and this may be added to the other reasons, already alluded to, for preferring the median cephalic for bleeding. Distressing symptoms follow such accident, which are principally referred to the digital terminations of the nerve: this fact Mr. Abernethy pointed out as indicating the difference between a wound of this and division of one of the cutaneous branches; in the latter case, the skin of the forearm is the seat of numbness and pain. These nerves, as well as the ulnar branches in the hand, are liable to injuries of various kinds. Tetanus is frequently the consequence of lacerated and contused wounds in this highly sensible organ. The proximity of the digital arteries and nerves should be borne in mind, in an attempt to place a ligature, in case of incised wound, on any portion of the palmar arterial arch: unnecessary intrusion of forceps into such a wound should be avoided, as it is usually vain to search for any individual branch as the cause of hæmorrhage; and the application of a ligature on one of these digital nerves is not at all unlikely to produce tetanic symptoms: a compress in the wound and on the arterial trunk is the most likely mode of arresting the bleeding without injury to nerves.

The terminations of the digital nerves swell, and are distributed in the soft pulpy cutis on the extremities of the last phalanges; which parts are thus endowed with a delicate sense of touch.

RADIAL NERVE.

Of equal size, and sometimes even exceeding the median, this nerve descends from the posterior part of the plexus, being situated behind the axillary artery: it then winds round the inner surface of the humerus to its posterior aspect, and thence to the outer condyle. In this course, it first lies between the inner and middle heads of the triceps, piercing their fibres; subsequently, as it passes outwards and downwards, it is placed between the external head of this muscle and the humerus; and after leaving the cover of the triceps, it is found deeply imbedded between the brachialis anticus and supinator radii longus muscles, and then emerges at the elbow-joint. It is accompanied in its winding course by the musculo-spiral branch of the superior profunda artery; and in the superior part of the arm, this nerve and vessel are separating the brachial artery from the triceps. The outer line of the humerus which gives attachment to the triceps, is grooved for the passage of this nerve, and some tendinous fibres passing from the external head of the muscle complete a canal in which it lies whilst behind

Radial.

Course.

the bone. At the elbow, this nerve divides into an anterior and posterior branch.

Branches. *Branches.* Opposite the tendon of the latissimus dorsi, three or four considerable branches are given to the several heads of the triceps; others again, which have the same destination, are separated whilst the nerve is taking its spiral course around the humerus; one passes to the anconeus muscle, and another usually becomes cutaneous. Opposite the origin of the supinator radii longus, whilst the nerve is between the brachialis anticus and outer head of the triceps, the radial cutaneous branch is given off; this usually pierces the brachialis anticus muscle, and winding round the supinator, descends on the outer and back part of the fore-arm to the wrist, distributing filaments in its course, and terminating on the skin of the thumb. Previous to its division, branches are given from the radial nerve to the supinators and extensors of the radius.

Anterior. The *anterior branch* is the smaller of the division at the elbow-joint, and becomes the companion of the radial artery through the middle third of the fore-arm. It lies first between the supinator longus and brevis, and subsequently under cover of the former and to the radial side of the artery, until it arrives at the junction of the middle with the inferior third of the radius; here it winds round between the bone and tendon of the long supinator to gain the outer and back part of the fore-arm, where it is found lying upon the extensors of the thumb: it divides, usually above the carpus, into an outer and inner branch: the *former* is distributed by three filaments to the radial margin of the thumb, and to the opposed borders of this and the index finger; the *latter* supplies the integuments on the ulnar side of the fore-finger, and on the middle finger[1]. The posterior annular ligament, the radio-carpal articulation, and the interossei muscles also receive filaments from these branches.

Posterior branch[2]; large, and destined to be distributed to the extensors and supinators of the fore-arm and hand: it takes a deep course outwards and backwards beneath the supinator longus and two radial extensors, to pierce the supinator brevis, thus lying very close to the neck of the radius. In this course, filaments are given to both supinators and both extensors: on emerging from the supinator brevis, which it perforates obliquely, it distributes numerous and large filaments to the extensors of the fingers and thumb, and to the anconeus; and is then continued onwards, much diminished in size, to the interosseous ligament along which it descends; and passing beneath the posterior annular ligament, terminates in the dorsal interossei muscles and integument on the back of the hand. Posterior.

[1] The ring finger is not infrequently supplied by this branch.
[2] Sometimes also named "*posterior interosseal.*"

Communications.

Communications. By the *radial cutaneous* branch, with the external cutaneous nerve. By the *posterior terminating* branch, with the last-mentioned and the dorsal branch of the ulnar; and also with the communicating filaments from the digital branches of the median.

The radial nerve derives branches from each of the three cords, but principally from the middle and inferior.

Remarks.

Remarks. In passing a ligature round the upper part of the brachial artery, this nerve is, perhaps, more liable to injury than the others, in consequence of its lying hid behind the artery: if the point of the needle be kept close to the vessel, the nerve cannot be included. In tying the superior profunda artery (if it be required) after amputation, the proximity of the radial nerve should not be forgotten. In like manner, in operations upon the radial artery, it should be known that the nerve lies to its radial side through the middle third of its course.

After amputation of the upper extremity, a condition of stump occasionally follows in which all the nervous trunks are more or less included at their terminations in a bulbous knotty expansion, the nature of which is not well understood. The cicatrized stump is conical in form, and the nipple-like apex is most acutely sensible. A second amputation must, in such cases, be resorted to. To avoid the possible occurrence of this condition of stump, Mr. Langstaff has recommended that the nerves should be drawn out and an extra portion cut off, after a limb has been removed: even this precaution, I have been assured, is not invariably successful.

Tabular view of the Axillary Nerves as distributed to Muscles.

Thoracic nerves.	Pectoralis major. Pectoralis minor.
Scapular nerves.	Subscapularis. Supra-spinatus. Infra-spinatus. Teres minor.
Circumflex nerve.	Teres minor. Infra-spinatus. Deltoid.
Two internal cutaneous nerves.	Give no muscular branches.
External cutaneous nerve.	Coraco-brachialis. Biceps. Brachialis anticus.
Ulnar nerve.	Triceps (*small*). Flexor carpi ulnaris. Flexor digitorum profundus. Flexor digitorum sublimis. Abductor, flexor brevis and adductor minimi digiti. Abductor indicis. Adductor pollicis. Two internal lumbricales. Anterior interossei.
Median nerve.	Flexor digitorum sublimis. Flexor digitorum profundus. Flexor pollicis longus. Flexor carpi radialis. Flexor carpi ulnaris. Palmaris longus. Pronator radii teres. Pronator quadratus. Anterior muscles of the thumb. Three outer lumbricales.

Radial nerve.	Triceps. Supinator radii longus. Supinator radii brevis. Extensor radialis longior. Extensor radialis brevior. Extensores digitorum. Extensores pollicis. Extensor indicis. Anconeus. Interossei dorsales.

The summary, then, is this: the *pectorals* and muscles about the *shoulder-joint* are supplied by the thoracic, scapular, and circumflex nerves: the *flexors* of the *fore arm* on the *upper arm*, principally by the external or musculo-cutaneous nerve: the *flexors* of the *carpus*, of the *fingers*, and of the *thumb*; the *pronators* of the *radius*, and the *palmar* muscles; the anterior small muscles of the *thumb* and *little finger*; the anterior *interossei* and *lumbricales*;—all receive their supply from the ulnar and median nerves: whilst the *extensors* of the *fore arm* on the *upper arm*, the *extensors* of the *fingers* and *thumb*, the *extensors* and *supinators* of the *carpus* and *radius*, and the *dorsal interossei*, have the branches of the radial appropriated to them.

DORSAL NERVES.

General description. The dorsal nerves consist of twelve pairs, which are smaller than the inferior cervical and lumbar nerves. The first pair leaves the spinal canal between the first two dorsal vertebræ, and the last pair between the twelfth dorsal and first lumbar vertebra.

In their mode of origin, the junction of their roots, and subsequent division into anterior and posterior trunks, they are precisely analogous to the cervical nerves[1]. It may be observed, that the lower we proceed the more acute is the angle formed between these nerves, after their exit from their respective foramina, and the spinal cord, i. e. their course approaches more nearly to the perpendicular. No plexus is formed in the dorsal region, as is the case in the cervical, lumbar, and sacral regions. The distribution of the dorsal nerves is therefore comparatively simple, and the branches are relatively few.

On leaving the intervertebral foramen, then, through which it passes, each nerve divides into a posterior and anterior trunk; the former set being called "*dorsal*," and destined for the muscles and skin of the back; the latter, "*intercostal*," taking their course between the ribs.

POSTERIOR OR DORSAL TRUNKS[2].

These are smaller than the anterior trunks; Posterior trunks.

[1] Unless we except that the fasciculi forming the roots take a longer course by the side of the spinal cord before they pierce the dura mater, which they do separately, as in the cervical region.

[2] For obvious reasons it is not deemed necessary to describe each posterior trunk individually, as was done in the cervical region.

they pass directly backwards between the transverse processes of the vertebræ, giving their first filaments to the semi-spinalis dorsi and multifidus spinæ, which, and the levatores costarum, they perforate. Some branches then pass between the longissimus dorsi and sacro-lumbalis, whilst others pierce these muscles and distribute filaments to them. To reach the skin they all pierce the trapezius; the two or three superior also perforating the rhomboideus major and serratus posticus superior, and the four inferior the latissimus dorsi tendon: these muscles and the serratus posticus inferior receive their supply from the posterior dorsal trunks, which subsequently terminate in the integument of the back.

The posterior trunk of the last dorsal communicates with that of the first lumbar nerve.

ANTERIOR OR INTERCOSTAL TRUNKS.

Anterior trunks.

Besides the difference in course and distribution that exists between many of the *anterior* or *intercostal* trunks of the dorsal nerves, there are characters possessed by them in common, which will first be noticed.

General characters.

1. Each intercostal nerve (for so we shall call them) communicates with the sympathetic by means of one or two filaments, received from the corresponding thoracic ganglion, which ascend obliquely outwards; the junction taking place

immediately external to the head of the rib[1]. 2. They are only covered by pleura till they arrive at the angles of the ribs; they then pass between the layers of intercostal muscles, and terminate in external and internal branches, of which the former become cutaneous. 3. After passing under cover of the internal intercostal muscle, each nerve approaches the rib above, running along its inferior margin in company with the intercostal vessels.

FIRST INTERCOSTAL NERVE.

This is the largest of these nerves. Immediately after its communication with the first thoracic or last cervical ganglion[2], it divides into two branches; the *inferior*, small, takes its course outwards along the inferior surface of the first rib, and, giving filaments to the intercostal muscles, pierces them near the sternum, and terminates in the skin of this region: some of these filaments 1st intercostal.

[1] This junction is described by some anatomists as taking place between the sympathetic and *anterior* root of the spinal nerve, and by others the reverse is believed to be the case. Professor Panizza states that he has satisfied himself, by manifold observations, that both the roots of the spinal nerves concur in the communication with the sympathetic. This was also the opinion of Scarpa and Soemmerring. See a paper by Professor Panizza in the Edinburgh Medical and Surgical Journal for January 1836, p. 71.

[2] The first thoracic and last cervical ganglia are sometimes one. See *Sympathetic*.

communicate with the supra-clavicular twigs of the cervical plexus. By far the larger division of the first intercostal nerve *ascends*, winding over the anterior margin of the first rib and behind the subclavian artery, to join at a right angle the eighth cervical nerve in the axillary plexus[1].

SECOND AND THIRD INTERCOSTAL NERVES.

2nd and 3rd. These differ from the others in giving off a *cutaneous brachial branch*. The *second* divides near the angle of the corresponding rib: the *internal* branch continues along the intercostal space, giving filaments to the muscles of that name, and terminates by becoming cutaneous near the sternum, when it distributes filaments to the pectoralis major, and adjacent skin and mamma. The *cutaneous brachial* branch, or superior nerve of Wrisberg, immediately after the division, pierces the external intercostal muscle, and then crosses the axilla, where it usually communicates with the internal cutaneous nerve of the arm, and is distributed to the skin of the upper arm. In the *third* pair, the division takes place about the middle of the rib. The *internal* branch passes forwards beneath the triangularis sterni muscle, giving filaments to it and the intercostals, and terminates as the last, near the sternum, in the skin and mamma. The *brachial cutaneous* branch,

[1] See *Axillary plexus*.

or inferior nerve of Wrisberg, is smaller than the superior, but has a similar course and destination.

FOURTH TO SEVENTH INTERCOSTAL NERVES INCLUSIVE.

These are similar in their course and distribution. They possess the characters common to all the intercostals, viz. after their communication with the sympathetic they run between the layers of intercostal muscles, and divide into an external and internal branch: this division occurs about the middle of the rib in these four pairs. The *internal* branches continue forwards till they arrive at the margin of the sternum, where they terminate in the skin and mamma, having previously distributed filaments to the triangularis sterni and intercostals. The *external* branches, on dividing, pierce the external intercostal muscles; each usually sends one filament forward, which is destined for the serratus magnus, external oblique muscle, or skin; and a posterior filament, which is lost in the skin of the lateral and posterior part of the chest. 4th, 5th, 6th, and 7th.

EIGHTH TO ELEVENTH INTERCOSTAL NERVES INCLUSIVE.

It will be remembered that the ribs, from the eighth to the twelfth, are decreasing in length. As the trunks of these intercostal nerves run for 8th, 9th, 10th, and 11th.

an equal length with those above them before their division, it necessarily follows that they divide nearer the external extremity of the rib. The distribution of their *external* filaments is precisely similar to those last described. The *internal* branches are given to the muscles of the abdomen: after leaving the intercostal spaces, they pierce the digitations of the diaphragm, and then pass forwards between the obliquus internus and transversalis abdominis, to terminate in the skin over the rectus: the principal filaments are, however, distributed to these three muscles[1].

TWELFTH INTERCOSTAL NERVE.

12th intercostal.

This nerve differs from the others in communicating, shortly after its origin, with the first lumbar nerve. It soon leaves the last rib, and crossing the superior margin of the quadratus lumborum muscle, gives filaments to it and the diaphragm, and then divides. The *internal* branch has the same course and distribution as those last described, whilst the *external* may be traced to the iliacus muscle and integuments of the anterior iliac region.

Remarks.

Remarks. The summary of the distribution of the *Dorsal nerves* is this: The *posterior* trunks supply the great mass of muscles in the dorsal re-

[1] I have not been able to satisfy myself whether the diaphragm receives any filaments from these branches: Mr. Swan, however, describes them as existing. (Swan's Nerves, p. 77.)

gion, and others moving the scapula and humerus; whilst many terminate in the skin. The *anterior* trunks are given to muscles which move the ribs, diminish the abdominal cavity, adduct the arms, depress the scapula; others, again, terminate in the skin of the belly.

List of muscles.

It will be remarked that many of the muscles to which the dorsal nerves are distributed, are more or less connected with and influencing respiration: the following is a list of them. In *inspiration*: intercostales; levatores costarum; serratus magnus; serratus posticus superior; rhomboideus; trapezius; pectorales; latissimus dorsi. In *expiration*: triangularis sterni; quadratus lumborum; obliqui, transversus, and rectus abdominis; serratus posticus inferior[2].

The intercostal nerves lie deeply in the groove of the rib, superior to the artery; they may, therefore, be avoided in the operation of paracentesis thoracis by the same precaution that is requisite for avoiding the vessels, viz. directing the lancet towards the inferior of the two ribs between which the puncture is made. In fractured rib the intercostal nerve may be wounded; it is, however, an injury of perhaps little importance compared with laceration of the artery, pleura, or lung.

[2] The filaments which supply these muscles are supposed by Sir Charles Bell to be derived from a continuation through the dorsal region, of the respiratory track described by him in the medulla oblongata. (Bell's Anatomy vol. ii. p. 545.)

LUMBAR NERVES.

Lumbar Plexus.	Inguino-cutaneous.	External.	To the skin of the iliac region.	
			To the scrotum.	
		Middle.	To the integuments of the upper part of the thigh.	
		Internal.	To the coverings of the cord.	
			To the groin and neighbouring skin.	
	Anterior crural.	Superficial.	Cutaneous branches of the thigh.	
		Deep.	External. Internal.	Muscular.
			Descending.	Great and small saphenus nerves.
	Obturator.	Solely muscular, to the adductors and external rotators of the thigh.		
	Lumbo-sacral.	Superior glutæal. Communicating.		

LUMBAR NERVES.

General description.

There are five pairs of lumbar nerves; the first pair escaping through the intervertebral foramina between the two first lumbar vertebræ; the last pair, between the fifth lumbar vertebra and upper part of the sacrum.

It will be remembered that the inferior of the three enlargements of the spinal marrow extends as low as the first lumbar vertebra, and then terminates in a fusiform or conical extremity, which is opposite the second vertebra and surrounded by the cauda equina. From this inferior expansion of the medulla spinalis the lumbar nerves arise, by roots which take a very oblique course within the vertebral canal, and form a part of the cauda equina. The formation of the ganglion on the posterior root, and the union between the two roots, take place in the intervertebral foramen[1]. The division of each nerve into anterior and posterior trunk occurs immediately after its exit.

POSTERIOR TRUNKS.

Posterior.

These trunks take a course backwards between the transverse processes of the vertebræ, pierce

[1] "It is not a very rare occurrence for some of the ganglia of the lumbar and sacral nerves to be double; and in every example of this sort I have carefully examined, the anterior bundle has also divided equally to join the anterior point of each divided ganglion."—*Swan, Med. Gaz.*, vol. xiv. p. 848.

the multifidus spinæ, sacro-lumbalis, and latissimus dorsi, to which they distribute filaments, and then terminate in the integuments about the loins, hip, and upper and back part of the thigh. In *size* they decrease from the first to the last.

ANTERIOR TRUNKS.

Anterior.

The anterior trunks of these nerves are hidden, as they emerge from the foramina, by the psoas magnus muscle. *Each* receives a filament from one of the lumbar sympathetic ganglia: the *first* also communicates with the last dorsal nerve; the *second*, with that above and below it, *i. e.* the first and third; the *third*, with the second and fourth; the *fourth*, with the third and fifth; the *fifth*, with the fourth and first sacral. An interlacement thus takes place behind the psoas muscle, extending from the second to the fourth lumbar vertebra, and resting on the anterior surface of the bases of the transverse processes: this is named the *lumbar plexus*.

Lumbar plexus.

BRANCHES OF THE LUMBAR PLEXUS.

Branches.

The branches derived from the lumbar plexus are,—inguino-cutaneous, anterior crural, obturator, lumbo-sacral.

INGUINO-CUTANEOUS NERVES.

These, which are not in all instances regular, are variously named and described in different anatomical works: they are three in number, and the following distribution will be found the most usual.

External inguino-cutaneous: also named *ilio-scrotal*, from its destination. After emerging from the psoas, and in its oblique passage towards the posterior part of the crest of the ilium, this nerve lies under cover of the peritoneum and crosses the quadratus lumborum muscle: after a short course it pierces the transversalis muscle, being then between it and the internal oblique; to these and the iliacus it gives filaments, and soon divides into two branches[1]. The *iliac* branch, perforating the oblique muscles, is distributed to them and the integument of the glutæal region: the *scrotal* branch continues its course forwards beneath the internal oblique muscle to the inner abdominal ring: it then traverses the inguinal canal, pierces the fascia of the external ring, and is distributed to the skin of the pubes, groin, and scrotum, and ultimately to the coverings of the cord. In the *female* it passes with the round ligament to the mons Veneris, and filaments are given to the labia. External inguino-cutaneous.

Middle inguino-cutaneous nerve[2]. This is the proper external cutaneous nerve of the thigh: it takes its course downwards and outwards, being Middle inguino-cutaneous.

[1] Not unfrequently a higher division takes place.

[2] It will be remarked that the title "*inguino-cutaneous*" is not equally applicable to all these nerves; the present nomenclature is adopted as being the least confusing.

internal to the last, and lying between the fascia iliaca and peritoneum. It pierces the abdominal muscles obliquely, and making its appearance immediately anterior to the superior spinous process of the ilium, it divides into two filaments which pierce the fascia lata, usually separately: one passes backwards and is distributed to the skin of the posterior part of the thigh; the other is larger, and frequently descends a short distance before it pierces the fascia; on becoming subcutaneous, it takes its course downwards along the outer and fore part of the thigh, distributing filaments to the skin; it may be traced as far as the knee.

Internal inguino-cutaneous.

Internal inguino-cutaneous nerve; also named *genito-crural.* After piercing the psoas and investing fascia, it descends nearly perpendicularly along the anterior surface of that muscle and behind the peritoneum, to near the centre of the crural arch; it then divides into two branches. The *genital* branch is the proper external spermatic nerve; through the inguinal canal it accompanies the cord, and is distributed to its investments, the dartos, and skin of the scrotum [1]. The *crural* branch descends between Poupart's ligament and the femoral vessels, its distribution being to the glands and skin of the groin, and

[1] It should be remembered that the testicle itself receives no filaments from these nerves, but is supplied from a different source, viz. the renal plexus of the sympathetic.

upper and anterior part of the thigh, in company with cutaneous branches from the anterior crural.

The inguino-cutaneous nerves are derived from the anterior trunks of the two first lumbar nerves. Derivation.

Remarks. An acquaintance with the distribution of these nerves and the posterior lumbar trunks, though not of much practical importance to the surgeon in his operations, is still interesting, as affording marked instances of the sympathy that exists between distant organs which derive their nervous supply from the same source. "We ought not, therefore, to dismiss the consideration of these nerves, without putting the knowledge of their distribution to some use." Remarks.

1. In the female, disordered function of the uterus is constantly attended by pain in the back and loins; and in the male, the same symptoms accompany diseased testicle.

2. The groin and perinæum are the frequent seats of pain in disordered rectum and bladder.

3. Diseases of the kidney and ureter produce pain down the fore part of the thigh, and retraction and pain of the testicle[2].

[2] I make these remarks on the authority of Sir Charles Bell: they are, however, obvious to every one familiar with disease.

ANTERIOR CRURAL NERVE.

Anterior crural.

Formed by branches which converge from different parts of the plexus, this nerve is at first deeply placed beneath the psoas magnus muscle:

Course.

as it passes downwards and forwards, it emerges on the outer border of this muscle, and continues its course between it and the iliacus and under cover of the fascia iliaca, towards the crural arch. As it passes beneath Poupart's ligament, it is resting on the conjoined margins of the psoas and iliacus, though more upon the latter, and separated from the femoral artery by the former; being, therefore, quite independent of the sheath of the vessels. Immediately afterwards it divides into its terminating branches, which are superficial and deep[1].

Branches.

Branches. In its course above Poupart's ligament, whilst between the psoas and iliacus, it gives off its first filaments to these muscles.

Superficial.

The terminating *superficial branches* are not very regular in number: there are usually three or four which pierce the fascia lata separately, at variable distances, but usually about an inch, below Poupart's ligament: on becoming subcutaneous, they soon divide into many filaments which descend on the inner and fore part of the thigh, accompanying and on either side of the

[1] Occasionally, though rarely, this splitting into branches takes place above the crural arch.

saphena vein; they assist in supplying the integuments in this region, and some may be traced over the inner condyle, to terminate in the neighbouring skin.

The *deep branches* are external, internal, and descending.

The *External deep* fasciculus is the largest division: it consists of a lash of branches which pass outwards; the most anterior pierce the sartorius and terminate superficially; others pass between the rectus, cruræus, and iliacus, in which they terminate. The rectus is always perforated by one or more large branches, which are then distributed to the vastus externus, cruræus and tensor vaginæ femoris, and even to the hip-joint. Deep.

The *Internal deep* fasciculus consists of comparatively few branches, which terminate in the vastus internus, pectinæus, and sartorius.

These divisions of the Crural nerve are pierced by the external circumflex artery of the thigh; and those filaments which descend in the extensor muscles are accompanied by its branches.

The *Descending deep* branches are two in number.

The *Small saphenus nerve* is at first found connected to the anterior part of the femoral sheath: it subsequently passes outwards, lying beneath the sartorius and giving it filaments: and then descends to the knee, terminating in the vastus internus. Saphenus nerves.

The *Great saphenus nerve* becomes one of the cutaneous nerves of the leg[1]: it is internal to the last, and accompanies the femoral artery throughout the thigh. At first it is superficial to this vessel, but subsequently becomes closely applied to its outer side[2], which relation it preserves till the artery arrives at the opening in the adductor magnus. They then part company, and the nerve proceeds downwards and forwards, beneath the sartorius and guided by the great adductor tendon, over the inner condyle of the femur; in which course it is accompanied by the anastomotica magna artery. It then becomes superficial, being situated between the tendons of the sartorius and gracilis muscles, and continues its descent on the inner side of the leg, accompanying the saphena vein for the rest of its course; and having passed together anterior to the inner malleolus, the nerve terminates on the dorsum of the great toe. The filaments which this nerve gives off in its passage, are distributed to the adductor magnus and sartorius; to the skin of the thigh and leg, and to the knee-joint.

Communications.

Communications. The *Anterior crural* nerve

[1] I have seen the saphenus nerve completely distinct from the anterior crural in the pelvis; running through the centre of the psoas muscle, but becoming closely applied to the crural trunk at their passage beneath Poupart's ligament.

[2] The dragging of the saphenus nerve in this situation by femoral aneurism, frequently occasions acute pain in the course of this nerve as far as the great toe.

communicates by the great saphenus branch as it is passing beneath the sartorius, with a filament sent from the obturator nerve; and frequently by the same branch, with the peroneal nerve on the foot. The different cutaneous nerves of the thigh also communicate.

The anterior crural nerve is *formed* by branches from the four upper lumbar nerves: the smallest is that from the first lumbar, and it is sometimes wanting. Formation.

Remarks. In taking up the femoral artery in the superior third of the thigh, the divisions of the anterior crural nerve are found on its outer side, the small saphenus branch alone being usually anterior but external to the sheath of the vessels. In performing the inferior operation, i. e. passing a ligature round the artery in the middle third of its course, the great saphenus nerve is on its outer side, within the sheath; it should be drawn outwards by a blunt hook, previous to securing the vessel. The connexion between the saphenus nerve and great anastomotic artery should not be forgotten; for this vessel is very deep at its origin, and frequently very large: "These facts," observes Dr. Harrison, "have caused this branch to be mistaken for the femoral trunk, in the inferior operation for aneurism[3]." Care should also be taken, after amputation of Remarks.

[3] Surgical Anatomy of the Arteries, vol. ii. p. 151.

the thigh, to avoid including the saphenus nerve in the ligature placed upon the artery: this occasions twitchings in the stump, and a good deal of distress. (*Bell.*) Branches of this nerve, or the nerve itself, may be punctured in opening the saphena vein anterior to the inner malleolus; the results are similar to those which follow a like accident in the upper extremity. Many cases may be met with in works on surgery, of unpleasant and even dangerous symptoms consequent on injury to the saphenus nerve[1].

Another remark, connected with amputation generally, but more particularly applicable to the thigh, is worth recording. Between the skin and fascia there is a loose cellular texture, and under that the cutaneous nerves run close upon the fascia. The practical utility of being acquainted with this fact, is thus illustrated by Sir Charles Bell. "If you place your knife at the edge of the retracted skin, you divide the cutaneous nerves at least an inch and a half, or more, shorter than the integuments, and the latter completely covers and envelopes their extremities. This is a very essential part of the operation to

[1] Thus, we read of tetanus being produced by a bruise of this nerve, as it passes over the tibia: and Sir Charles Bell mentions an instance of extreme and long suffering occasioned by injury to this nerve with the lancet; and another somewhat similar, from a wound with a small-sword. (Anatomy, vol. ii. p. 622.)

be attended to, and is too often neglected, giving rise to conical stumps[2]."

OBTURATOR NERVE.

This nerve, at its separation from the plexus, lies under cover of the psoas magnus, and close to the body of the last lumbar vertebra. It descends at first nearly vertically, and subsequently takes its course along the level of the upper brim of the pelvis to the thyroid foramen. In this course, it lies between the pelvic fascia and peritonæum, inferior to the external iliac vessels, and on a plane posterior and internal to the anterior crural nerve, the psoas muscle being interposed between them. Previous to arriving at the thyroid foramen, the nerve is joined by the corresponding artery and vein, and lies between them, the artery being usually, but not invariably, uppermost. The opening through which these parts escape from the pelvis is situated at the upper part of the thyroid foramen, the bone being grooved obliquely and the membrane wanting in that situation: the inclination of the aperture is from behind forwards and inwards. In passing this opening, the above parts pierce the pelvic fascia, upper margin of the levator ani, and internal obturator muscle. The nerve is then found in the thigh, under cover of the pectineus

Obturator.

Course.

[2] Clinical Remarks. (Med. Gaz. vol. xiv. p. 185.)

and adductor longus, and lying on the obturator externus: it here divides.

Branches. *Branches.* Within the pelvis, a filament is given off which descends to the obturator muscles. The *superficial* terminating branches are usually three, and are situated between the adductor longus and brevis; they are distributed respectively to these muscles and the gracilis: one or two filaments become cutaneous. The *deep* terminating branch lies between the adductor brevis and magnus; it supplies these muscles and the obturator externus with filaments; one or two of these may be traced some way down the thigh[1].

Communications. *Communications.* The obturator nerve communicates on the vastus internus, by its branch to the adductor longus, with the great saphenus nerve.

Origin. The obturator nerve is derived principally from the anterior trunk of the third lumbar; also receiving a branch from the second, and frequently one from the fourth.

Remarks. *Remarks.* There are no points of practical importance connected with this nerve, except the sympathy, already noticed, existing between it and the pelvic nerves. It is not likely to be interfered with in passing a ligature round the ex-

[1] The hip-joint also receives a filament. (Swan's Nerves, p. 87.)

ternal iliac artery, being quite posterior to this vessel. Probably the acute pain accompanying dislocation of the head of the femur into the foramen ovale is in part referable to injury of this nerve.

LUMBO-SACRAL NERVE.

This is the largest branch of the lumbar plexus, from the inferior part of which it descends, a little internal to the sacro-iliac articulation, towards the ischiatic plexus ; and divides into two branches. Lumbo-sacral.

Branches. The *superior glutæal* nerve leaves the pelvis by the great ischiatic foramen, above the pyriformis muscle and in company with the glutæal artery: it is distributed with the branches of that vessel to the two smaller glutæi muscles. Superior glutæal.

The *communicating* branch is the continuation of the trunk, being a short and large nerve: it crosses the glutæal artery, and joins the upper part of the ischiatic plexus. Communicating.

The lumbo-sacral nerve is *formed* by the whole anterior trunk of the fifth, and a branch from the fourth lumbar nerves. Origin.

Tabular View of the distribution of the Lumbar Plexus to Muscles.

Lumbar Plexus.	Inguino-cutaneous.	Obliqui et traversalis abdominis. Iliacus internus. Cremaster. Also many cutaneous to the thigh and nates.
	Anterior crural.	Psoas. Iliacus. Tensor vaginæ femoris. Sartorius. Rectus. Cruræus. Vasti. Adductor magnus. Pectinæus. Also many cutaneous to the thigh and leg.
	Obturator.	Obturatores, externus et internus. Adductores, longus, brevis et magnus. Pectinæus. A few cutaneous to the thigh.
	Lumbo-sacral.	Glutæi, medius et minimus. Communicating.

SACRAL NERVES.

The sacral nerves consist of five, or sometimes six, pairs; they are derived from the extremity of the spinal cord, which, it will be remembered, ceases opposite the second lumbar vertebra, and by their almost vertical descent through the lower part of the vertebral and the sacral canal, form that peculiar appearance which is named "*cauda equina*." The union of the anterior and posterior roots takes place within the sacral canal, and is soon succeeded by the division into anterior and posterior trunks, which leave the canal by the corresponding sacral foramina[1].

POSTERIOR TRUNKS.

Posterior.

These are very small, especially the two last: immediately after escaping from the posterior sacral foramina, they communicate, the first with the last lumbar, and the rest with one another, and then pierce the sacro-lumbalis muscle, terminating by being distributed to it and the neighbouring integument of the nates and anus.

ANTERIOR TRUNKS.

Anterior.

Of the anterior trunks, the four first, after communicating with the sacral ganglia and hypogastric plexus, become connected to form the sciatic plexus. The two inferior are smaller and have scarcely anything to do with that plexus; but after communicating with one another and the fourth, are at once distributed to the coccygeus and muscles of the anus.

[1] The four first pairs of course leave by the sacral foramina, and the fifth as invariably by the foramen which is formed at the junction of the sacrum and coccyx. When a sixth exists, it is very small, and is lodged in the lateral notched margin of the coccyx.

- Sciatic Plexus.
  - Visceral.
    - Hæmorrhoidal-vesical.
    - Uterine-vaginal.
    - Pudic.
      - Dorsalis penis.
      - Perinæal.
  - Femoro-crural.
    - Small Sciatic.
      - Inferior glutæal filaments.
      - Ischiatic or musculo-cutaneous.
      - Posterior cutaneous.
    - Great Sciatic.
      - Muscular filaments.
      - External Popliteal.
        - Fibular.
        - Anterior tibial.
        - Communicating.
      - Internal Popliteal.
        - Communicating.
        - Muscular.
        - Posterior tibial.

SCIATIC PLEXUS.

The bulk of this plexus is formed by the communicating branch of the fifth lumbar, and the anterior trunks of the four first sacral nerves, the one or two last being distributed, as already noticed, to the muscles about the anus.

Plexus. The sciatic plexus cannot be seen until the pelvic viscera are detached from their connexions and drawn forward, without, however, being removed: Its position. its situation is deep in the pelvic cavity, lying on the lateral part of the sacrum and pyriformis muscle, and behind all the pelvic viscera: it is also posterior to the internal iliac artery and its branches, to which it is connected by a quantity of adipose cellular tissue. Form, &c. Its *form* is triangular, the base being above at the exit of the nerves from the sacral foramina, its base below, where they join to form a single flattened cord. The *mode* in which the various trunks pass to form this plexus differs from that of every other plexus in this respect, that there is *no interlacement* of branches, but a simple and direct junction to form a single cord[1].

The following arrangement of the branches of the sciatic plexus is adopted as the most simple: they are divided into *visceral* and *femoro-crural*; under the first head are comprehended the hæmorrhoidal, vesical, uterine and vaginal, and pudic branches; under the second we enumerate the small sciatic and the great sciatic nerves.

VISCERAL BRANCHES[2].

Hæmorrhoidal. These consist of *ascending* and *descending* filaments; the former are distributed to the lower part of the sigmoid flexure of the colon, and to the upper part of the rectum; the latter pass to the lower part of the rectum and anus. Both the muscular and mucous tunics are supplied by these filaments. Visceral branches.

Vesical. These pass forwards on the lateral part of the rectum, and are distributed to the

[1] It is therefore evident that the title '*plexus*' is inapplicable in this instance.

[2] The student need scarcely be reminded that all these branches lie posterior and external to the peritonæum, and therefore have not to pierce that membrane.

bladder, prostate gland, and vesiculæ seminales.

Uterine and *Vaginal*. These take a course similar to the preceding, and supply the uterus and vagina.

Communications. All these nerves communicate freely with one another, and with the filaments derived from the lumbar and sacral ganglia of the sympathetic, which have a similar destination[1].

These branches are *derived* from the third and fourth sacral nerves.

Remarks. *Remarks*. It is of importance that the student should remember the communications above enumerated, in as much as they serve to explain the otherwise obscure symptoms arising from sympathetic derangement of these viscera, dependent on functional or other changes in some unsuspected or even distant organ.

Pudic. *Pudic nerve*[2]. This is a considerable and important branch, derived from the inferior part of the plexus. The trunk of this nerve leaves the pelvis by the great sacro-sciatic foramen, beneath the pyriformis muscle, and in company with the

[1] For further particulars and physiological remarks, see "*Hypogastric plexus.*"

[2] The propriety of classing this with the *visceral* branches may naturally be questioned. It must be remembered that *any* classification is arbitrary, and that the above was selected for its simplicity: in function the pudic nerve is more nearly allied to the visceral than the other division of the plexus.

external sciatic branches: it then winds round the spinous process of the ischium close to the pudic artery, and accompanies that vessel at its re-entrance into the pelvis through the lesser ischiatic foramen: after this it divides into a superior and inferior branch. We shall first trace the distribution of these in the male.

The *superior* branch takes its course, in company with the pudic artery, along the inner margin of the ramus of the ischium and pubis, protected by the pelvic fascia: arrived at the symphysis pubis, it passes beneath it and above the crus penis of the same side, and thence runs along the dorsum of the penis, in company with the corresponding artery, to terminate in the glans penis. This branch gives filaments to the erector penis and accelerator urinæ muscles; also to the urethra and neighbouring integuments; but its principal distribution is to the glans penis, corona glandis, and prepuce. Distribution in the male.

The *inferior* or *perinæal* branch accompanies the last-described along the inner surface of the tuber ischii; it then becomes superficial by passing forwards between the erector penis and accelerator urinæ. The *distribution* of this branch is in company with the perinæal branch of the pudic artery, viz. to the muscles of the anus and transversi perinæi; to the urethra and its muscles; and, lastly, to the dartos and neighbouring integument.

In the female.

In the *female*, the *superior* branch is very small and terminates in the clitoris; whilst the *inferior* branch is larger than in the male, having to supply, in addition to the perinæum, the labia and nymphæ, and terminating in the mons Veneris.

Communications.

Communications. The pudic nerve communicates, at its origin, with the small sciatic, and subsequently with the visceral branches of the plexus and with its fellow.

It is *derived* principally from the third and fourth sacral nerves.

Remarks.

Remarks. This nerve is liable to injury as well as the pudic artery, in the lateral operation of lithotomy; but wounding the latter is of incomparably greater moment. The pudic is a remarkable nerve, "for," as Sir Charles Bell observes, "besides being the organ of venereal sensation, it bestows the sensation which orders the contraction of the bladder, not only furnishing us with these sensations in addition to the common sensibilities, but under the influence of these sensations it controls the various necessary actions of the muscles:" and, it may be added, is capable by its influence of exciting the penis to a state of erection.

FEMORO-CRURAL BRANCHES.

Under this head are included those branches which are destined to supply the glutæal, femoral, and crural regions, viz. the small and great sciatic nerves.

SMALL SCIATIC NERVE.

This nerve is derived from the middle and lower part of the plexus, and leaves the pelvis, usually as a single trunk, in company with the great sciatic nerve and by the larger ischiatic foramen, below the pyriformis muscle; it then divides into three sets of filaments,—inferior glutæal, ischiatic or musculo-cutaneous, and posterior cutaneous[1].

Inferior glutæal branches. These consist of a lash of filaments which divide into ascending and descending, and are distributed exclusively to the glutæus maximus muscle. Inferior glutæal.

Ischiatic branch. This ascends and then curves inwards beneath the tuber ischii: it divides into filaments, of which a few are distributed to the glutæus maximus muscle, and the rest become cutaneous and terminate in the skin of the perinæum and inner femoral region. Ischiatic.

Posterior cutaneous branch is the largest division of the small sciatic nerve: it descends external to the other two, and emerging from the cover of the glutæus maximus, continues its course Cutaneous.

[1] This division sometimes takes place within the pelvis, and each branch may, by dissection, be traced coming off separately from the plexus. The description is frequently given in this way.

beneath the fascia lata to the popliteal region, where it becomes cutaneous and divides into three or four filaments which are distributed to the integuments of the posterior crural region. In this course it gives off a few cutaneous filaments to the nates, and numerous twigs which pierce the fascia and are distributed to the skin on the back of the thigh.

Communications and origin.

Communications. With the pudic nerve, and by its cutaneous branch in particular, with the other cutaneous nerves of the thigh.

The small sciatic nerve may be *traced* back to the second, third, and fourth sacral nerves.

Remark. The same practical remark is applicable to these as to the lumbar nerves and visceral branches of the sacral.

GREAT SCIATIC NERVE.

Course, &c.

This, which is the largest nerve in the body, may with propriety be called the continuation, rather than a branch, of the sacral plexus, from which the other branches are but offsets. The several roots becoming conjoined, this large cord, flattened from before backwards, is formed. It is found, within the pelvis, resting upon the anterior surface of the pyriformis muscle, which it crosses at a right angle: it then escapes from the pelvic cavity by the great ischiatic foramen, between the pyriformis and superior gemellus muscles[1], and descends under cover of the glutæus maximus in the hollow between the tuber ischii and trochanter major, crossing and, as it were, binding down the gemelli, obturator internus, and quadratus femoris muscles. In its subsequent descent it passes over the adductor magnus, and is overlapped by the opposed edges of the biceps and semitendinosus: in the popliteal space its ultimate division by bifurcation is seen[2].

Branches. As this is principally a crural nerve, its *femoral* branches are comparatively small and few: they are not very regular, and may be simply enumerated as supplying the muscles with which the trunk lies in contact in its passage down the thigh, viz. filaments to the small external rotators, adductor magnus, and glutæus maximus[3]: the other filaments are distributed to the ham-string muscles, a few of which become cutaneous and communicate with the posterior cutaneous nerve. Branches.

In pursuance of an object which it is intended should form a prominent feature in this manual, viz. attention to relative practical anatomy, the

[1] It not infrequently occurs that this nerve is divided by the interposition of a portion of the pyriformis muscle; and that division corresponds to the bifurcation which does not usually take place till the nerve approaches the ham.

[2] The point of *bifurcation* of the great sciatic nerve is very irregular: sometimes the two cords may be traced separately even up to their origin within the pelvis, and generally a little dissection will effect this division for a considerable distance.

[3] Sometimes the inferior glutæal nerve being very large supplies the place of *these* glutæal twigs. (See Cloquet, p. 510.)

student is requested to give his attention for a few moments to the boundaries and contents of the popliteal space.

Ham. This region is situated at the junction of the thigh and leg, and on the posterior aspect of the limb. It is a diamond-shaped space, its longest axis being vertical: its superior angle is formed at the commencing point of divergence of the ham-string muscles; its inferior angle at the point of union of the two heads of the external gastrocnemius; whilst its sides and lateral angles are formed by the approximation of the heads of the last-named muscle with the biceps externally, and semi-membranosus and semi-tendinosus internally. The posterior aspect of this region is covered in by integument and the dense fascia descending from the thigh to the leg; and the knee-joint with its ligamentous appendages and the popliteus muscle form its anterior boundaries. Its *contents* consist of the popliteal artery, vein, and nerves, and a quantity of adipose tissue with some lymphatic glands and vessels.

Contents.

The relative situation of these parts is this: the artery deepest, i. e. nearest to the joint; the vein covering it posteriorly, and therefore more superficial; whilst the nerves are nearest the surface, and separated from the vessels by some adipose tissue. Lymphatic vessels may here and there be traced entering the lymphatic glands which are small and scattered.

Remarks. A knowledge of the above relation of parts teaches us that the position of the nerves subjects them to pressure from aneurismal enlargement of the popliteal artery: thus, Boyer remarks, what every surgeon has observed in advanced cases, that "the distention of the sciatic nerve by the popliteal aneurism sometimes brings on intolerable pain, which extends to all parts to which this nerve is distributed." A degree of numbness is, however, not infrequently the result of such pressure, and this even accompanying pain. All these symptoms may, nevertheless, be referred to pressure from other causes, such as enlargement or suppuration of the lymphatic glands, growth of tumors, &c. The author above quoted says that he has seen an artery the size of the radial, descending in the sciatic nerve, and forming a collateral branch of communication in a case of aneurism. Remarks.

INTERNAL POPLITEAL NERVE.

This nerve, on separating from the external branch, takes nearly a perpendicular course along the outer margin of the semi-membranosus muscle, by which it is conducted to the space between the heads of the gastrocnemius; and then dipping beneath the solæus, becomes concealed from view. In this course, it is covered by the dense popliteal fascia, and crosses the posterior aspect of the popliteal vessels and muscle, sepa- Internal popliteal.

rated, however, from the former by more or less adipose tissue. The solæus muscle must now be raised to trace this nerve in its course through the leg[1]. After having traversed the fibrous aperture of the solæus, it is found situated between this and the deep layer of muscles: it now takes the name of *posterior tibial* nerve, and in its descent to the inner malleolus, has the following relations; in the two upper thirds of the leg, it is *covered* by the gastrocnemius and solæus muscles; and in the lower third, it gradually emerges from the cover of the tendo Achillis, and is then only protected by the fascia. It first *lies* on the tibialis posticus muscle, and lower down on the flexor communis digitorum; being accompanied by the posterior tibial artery, which is situated on its inner side. As the posterior tibial nerve leaves the inner malleolus to traverse the arch of the os calcis, it divides into its two ultimate branches: this bifurcation is sometimes concealed by the origin of the abductor pollicis. The following *branches* are derived from this nerve.

Course.

Posterior tibial.

Communicans tibialis[2]: arises opposite to or a little above the inner condyle of the femur, and

Communicating.

[1] Though this order is followed in the description, the dissector must examine the superficial branches first, or take care to avoid injuring them in laying bare the deep ones.

[2] Or *external saphenal* branch. The name "external" is given in reference to the distribution rather than the course of this nerve.

joining the small saphena vein, accompanies it down the posterior part of the leg, between the gastrocnemius muscle and crural aponeurosis. In its descent it inclines outwards towards the external malleolus, a few inches above which it receives a considerable communicating filament from the external popliteal nerve[3]; after this reinforcement it takes the name of *external saphenus* nerve. Having next crossed the peroneal muscles, it winds behind the outer ankle, still accompanied by the vein, and opposite the base of the fifth metatarsal bone it divides. In its course down the leg, this branch gives off cutaneous filaments, and others which are distributed to the posterior part of the ankle-joint: of the terminating filaments, the *external* passes forwards along the outer margin of the foot, and after supplying the abductor minimi digiti, is lost on the little toe: the *internal* proceeds along the dorsal surface of the fourth metatarsal bone, and is distributed to the opposed sides of the two last toes.

In the ham, the internal popliteal nerve gives off *muscular* branches which are distributed to the gastrocnemius, solæus, popliteus, and plantaris muscles: many of these filaments are large and accompany the muscular branches of the popliteal artery, whilst others pass to the knee-joint. Lower down are given off long filaments Muscular.

[3] Communicans peronei.

which pass off on either side to supply the different muscles composing the deep layer. A communication is moreover established between this and the *anterior* tibial nerve, by a branch passing through the superior aperture in the interosseous ligament; this is subsequently given to the anterior tibial muscles. Cutaneous filaments are separated during the descent of this nerve: and lastly, a considerable and regular branch is given off near the ankle, usually immediately before, but sometimes just after the bifurcation; this becomes superficial, and passing downwards and forwards, is distributed to the skin of the sole of the foot. The terminating branches are the two plantar.

Cutaneous.

Tendons, &c. at inner ankle.

Before the student proceeds to the dissection of the plantar nerves, let him examine the relation of parts at the inner ankle. The tendons of the tibialis posticus and flexor digitorum communis are here found changing their relative position, and each inclosed in its own proper theca: the large tendon of the former lies in close apposition with the internal malleolus, and is therefore most internal and anterior; next in order, and immediately behind and below the last, is found the tendon of the flexor communis; a considerable interval then exists between these and the flexor pollicis, in which lie the artery with an accompanying vein on either side, anteriorly, and the tibial nerve dividing into its plantar branches, posteriorly. Now the tendons of the two flexors change their relative position in the sole of the foot, that of the flexor pollicis crossing *above* the other to its tibial side. In like manner the relation of these tendons to the plantar nerves is altered in a subsequent part of their course; and this part of the description we may here anticipate by noticing, that the internal or larger division of the posterior tibial nerve, just as it enters the plantar region, gradually inclines from the inner to the outer side of the flexor pollicis tendon; whereas, the outward tendency of the flexor communis places the nerve in question on the inner or tibial side of this muscle. The external plantar nerve, as will be hereafter seen, crosses the arch of the foot to gain the outer side of both these muscles.

Internal Plantar.

Internal Plantar nerve, larger than the external, takes a horizontal course forwards to the base of the metatarsal bone of the great toe, obliquely crossing above the abductor pollicis, and subsequently running forwards in the interval between it and the flexor brevis digitorum, and parallel to the long flexor tendons[1]. After giving filaments to the muscles of the great toe, flexor brevis, and accessorius digitorum, it divides into four branches which are distributed in the following order: the *first* takes its course along the inferior

[1] To expose this division, the abductor pollicis should be carefully divided through its centre, and reflected.

surface of the flexor brevis pollicis, and terminates on the tibial side of the great toe: the *second* runs in the first interosseal space along the outer side of the flexor pollicis tendon, and, after giving filaments in its passage, bifurcates at the metatarso-phalangeal articulation; the two secondary twigs are distributed on the fibular side of the great toe, and tibial side of the second: the *third* passes in the second interosseal space, and is distributed to the opposed margins of the second and third toes: the *fourth* is distributed in a similar way between the third and fourth toes.

External Plantar.

External Plantar nerve. From the inner ankle this nerve crosses the foot obliquely to the base of the fifth metatarsal bone, where it divides. In this course it passes between the flexor brevis digitorum and flexor accessorius, to which, and the abductor minimi digiti, filaments are given. Of its division, the *superficial* branch terminates by subdividing, sending one filament along the fibular side of the little toe, which also supplies the flexor brevis minimi digiti, and another which is distributed along the opposed margins of the two last toes, communicating with the most external branch of the inner plantar nerve. The *deep* branch accompanies the external plantar artery to the inner side of the foot, passing above the adductor pollicis, and terminating in the interossei: it forms an arch in its course, and also gives filaments to the adductor pollicis, transversalis pedis, and lumbricales, and communicates with the inner plantar.

It will be remarked, that in their ultimate distribution the internal plantar nerve corresponds to the median, and the external to the ulnar nerve in the hand.

Communications. The internal popliteal nerve communicates with the external by its communicans tibialis branch; by small filaments sent through the interosseal aperture, with the anterior tibial; by its internal plantar branch, with the terminating internal branch of the anterior tibial. The plantar branches also communicate with each other. Communications.

Remarks. The relative position of the posterior tibial nerve and artery, both in the leg and at the inner ankle, should be remembered in placing a ligature on the latter; the nerve is more or less to the fibular side all along. With respect to the plantar nerves, the remarks which have already been made on the palmar branches of the median and ulnar, are equally applicable here. Remarks.

EXTERNAL POPLITEAL NERVE.

This nerve, which is not so large as the internal division, takes its course downwards and outwards along the biceps muscle to the outer condyle of the femur; then crossing the external head of the gastrocnemius, it winds forwards, under cover of the peroneus longus, round the neck of External popliteal.

the fibula, and there divides into two branches, anterior tibial and musculo-cutaneous. *Previous* to this division, filaments are given to the biceps muscle and capsule of the knee-joint; also two or three long *cutaneous* filaments[1]. The most regular branch is the *communicans peronei,* which descends under cover of the crural aponeurosis, and, below the middle of the leg and to the outer side of the tendo Achillis, joins the communicans tibialis from the internal popliteal[2].

Fibular. *Musculo-cutaneous* or *Fibular* nerve. This branch, which is the larger of the two, takes an oblique course downwards and inwards, beneath the head of the peroneus longus, and between it and the extensor communis digitorum; lower down it comes from under the peroneus, but continues its course beneath the dense fascia which covers the muscles in the anterior tibial region: a little below the middle of the leg it becomes subcutaneous by obliquely piercing the aponeurosis; and

[1] The origin of these branches, and their number, are subject to variety.

[2] The confusion arising from a various nomenclature I have frequently observed evidenced in this simple nerve; I may therefore stand excused for briefly recapitulating. The *internal* popliteal nerve gives off a branch, the *communicans tibialis,* which is joined by a branch from the *external* popliteal, the *communicans peronei*; the resulting trunk is named '*External Saphenus nerve.*' The confusion arises from the former of these two branches being sometimes at once named Saphenus, and the latter receiving no name at all. The point of their union is by no means regular.

before the anterior annular ligament of the ankle-joint, divides into its two terminating branches.

Branches.

Branches. This nerve supplies *muscular* filaments to the peronei and extensor digitorum communis; lower down, two or three *cutaneous* filaments, which are distributed over the outer malleolus and back of the foot. Of its *terminating* branches, the *internal*, after giving filaments to the dorsum of the foot, divides, and crossing above the tendons, is distributed to the muscles of the great toe and the skin on its tibial side, and to the opposed surfaces of the first two toes. The *external* branch, also crossing superficial to the tendons, divides on the metatarsus into three filaments which are distributed as follows: the internal, to the opposed margins of the second and third toes; the middle, between the third and fourth toes; and the external, between the fourth and fifth.

Anterior tibial.

Anterior Tibial nerve: the smaller division of the external popliteal nerve, and more entitled, together with the corresponding artery, to the name of anterior interosseal, from the course they take. After separating from the musculo-cutaneous branch below the head of the fibula, it winds round this bone beneath the peroneus longus and extensor digitorum communis, and thus gaining the interosseous ligament, descends in company with the anterior tibial artery, holding the same muscular relations, viz. between the tibialis anticus and extensor communis above; and below, between the former and extensor pollicis longus, gradually approaching the tibia which it crosses inferiorly. The relative position of the nerve and artery is, that the former is to the outer side above, but for a considerable part of its course lies anterior to the artery[1].

Branches. *Branches.* This nerve gives off *muscular* filaments to the three above-mentioned muscles, and some which pass upwards to the knee-joint. Of its *terminating* filaments, the *external,* passing beneath the extensor brevis digitorum, is distributed to this muscle and the anterior interossei; whilst the internal is continued forwards in company with, and to the outer side of, the anterior tibial artery, beneath the internal division of the extensor brevis digitorum, and is distributed ultimately to the contiguous borders of the first and second toes.

Communications. *Communications.* The external popliteal nerve is connected by its communicans peronei with the communicans tibialis of the internal popliteal;—by the internal terminating filament of its musculo-cutaneous branch, with the internal saphenus branch of the anterior crural:—a communi-

[1] It may occasionally be seen behind the artery in the inferior third of its course. This uncommon relation occasioned some difficulty in a case in which I saw a portion of this nerve removed, for neuralgic pain in the great toe and inner side of the foot: the operation proved successful.

cation exists on the dorsum of the foot between the musculo-cutaneous and anterior tibial nerves; lastly, the external saphenus nerve and the external terminating filament of the musculo-cutaneous branch also communicate in the skin on the outer and back part of the foot.

Remarks. The following points of practical importance connected with the branches of the external popliteal nerve should be attended to:—the relation of its anterior tibial branch to the corresponding artery, and their proximity to one another: this latter point should not be forgotten in placing a ligature on the artery after amputation; and this remark is equally applicable to all nerves in the extremities, whose relations are similar. The connexion of this nerve and its branches to the upper part of the fibula, may render them liable to laceration in fracture of this bone, and thus account for otherwise anomalous symptoms. The musculo-cutaneous, as well as the other cutaneous branches, is liable to division in incised wounds of the leg. Remarks.

REVIEW OF THE NERVES OF THE FOOT.

The plantar region is supplied by the plantar nerves;—viz. the little toe and fibular margin of the fourth toe, as well as the deep muscles, by the *outer* plantar, the rest by the *inner* plantar nerve. On the dorsum of the foot we find the inner surface supplied by the internal saphenus nerve; the two inner toes, by the terminating filaments of the anterior tibial and the inner division of the musculo-cutaneous; the four outer toes, by the external division of the musculo-cutaneous; the two outer toes and outer side of the foot are moreover supplied by the external saphenus nerve.

Tabular view of the Nerves of the Sacral Plexus, as distributed to Muscles.

Sacral Plexus.	Visceral.	To pelvic viscera.	
		Pudic.	Organs of generation.
			Erector penis. Accelerator urinæ.
			Levator and sphincter ani.
			Transversi perinæi.
			(in female) Sphincter vaginæ.
			Cutaneous to perinæum.
	Small Sciatic.	Glutæus maximus.	
		Otherwise, cutaneous to perinæum, thigh, &c.	
	Great Sciatic.	Small external rotators of thigh.	
		Glutæus maximus, adductor magnus.	
		Ham-string muscles.	
		Internal Popliteal.	Gastrocnemius. Solæus.
			Plantaris. Poplitæus.
			Flexor digitorum longus.
			Flexor pollicis longus.
			Tibialis posticus.
			Communicating filament to anterior tibial muscles.
			All the plantar muscles.
			Cutaneous filaments to leg.
		External Popliteal.	Peronei. Extensores digitorum et pollicis longus.
			Extensor brevis. Tibialis anticus.
			Dorsal interossei.
			Muscles of great toe.
			Cutaneous filaments to leg and foot.

It appears then, with respect to the muscles of the lower extremity, that the following is the general distribution of both lumbar and sacral plexus.

The glutæal region—consisting of glutæi and external rotators of the thigh—is supplied by the lumbo-sacral, small sciatic, and great sciatic nerves: the perinæal region by the pudic.

The anterior, internal and external femoral regions—consisting of adductors and some rotators of the thigh, and extensors of the leg—by the anterior crural and obturator nerves.

The posterior femoral region—consisting of flexors of the leg—by direct branches from the great sciatic nerve.

The posterior crural region, and plantar region—consisting of flexors of the foot and toes—by the internal popliteal nerve.

The anterior and external crural regions, and dorsal region of the foot—consisting of extensors of the foot and toes, and peronei—by the external popliteal nerve.

PART IV.

SYMPATHETIC SYSTEM.

PART IV.

SYMPATHETIC SYSTEM.

The division of the nervous system classed under this head is intricate; and in consequence of the different modes resorted to by authors, of describing the ganglia and their branches, the student is liable to become confused in the course of his dissection, and to a find difficulty in classifying for himself the many communications between the sympathetic and cerebro-spinal system, and the resulting ganglia. A few words in explanation may assist in dispelling these difficulties.

Nomenclature.

One source of confusion arises from the use of the term 'ganglionic,' as exclusively applied to the sympathetic system: but this is palpably incorrect, in that the external ganglionic nerves have at any rate an equal right to that title, whatever may be their function[1].

Again, some of the sympathetic ganglia are

[1] See Dr. Marshall Hall's Lectures on the Nervous System. This physiologist considers that ganglia are typical of or belong to the nerves which preside over the processes of assimilation.

frequently described under the head of the nervous trunks with which they communicate: thus, the ophthalmic ganglion is described with the first division of the fifth nerve; and the ganglion of Meckel with the second division of the same. This method, I conceive, must tend to render the dissection more intricate to the young student.

Plan to be adopted.

In the following description, each sympathetic ganglion and its branches will be described under the present division[1]. Notice is moreover taken of the communicating branches, under the head of each individual nerve receiving such communication.

A few words with respect to the structure and functions of ganglia may not be deemed irrelevant.

Ganglia.

Structure, &c.

The sympathetic ganglia are of a greyish-red colour, and are supposed to consist of an interlacement of fine nervous filaments held together by cellular tissue[2]. Their forms are various and irregular. They are found imbedded in cellular

[1] This plan is dependent for its correctness on the truth of the supposition that these ganglia really belong to the *internal* ganglionic or sympathetic system; that is, whether the existence of ganglia, (as on the second division of the fifth, in the orbit, &c.), is the result of a communication with the sympathetic. This is, to say the least, very doubtful; but whatever may be the *physiological* view of the subject, the simple *anatomy* cannot be interfered with by the present arrangement, which I believe coincides with the most generally received opinion on the matter in question.

[2] Scarpa.

tissue; each by itself being a small nervous centre, from which radiate filaments to the surrounding organs, and filaments of communication to other parts of the nervous system.

Boiling first hardens and subsequently softens them. They are partly soluble in alkalies, and long resist putrefaction[3]. In strong and robust subjects, every part of the sympathetic is much larger than in others of delicate form[4]. There are no ganglia in the extremities[5].

In perusing the few physiological remarks that follow, the student is requested to bear in mind that the functions of the sympathetic are by no means clearly understood or decided upon; these observations, therefore, can only be meant to embrace the most probable and consistent opinions upon the subject.

In the first place, as the term 'ganglionic,' when applied exclusively to this system, has been pointed out as likely to mislead and confuse, so the student must divest himself of any erroneous ideas he may have derived from the other and more common term made use of, viz. 'sympathetic.' It is certainly not exclusively, nor indeed generally, through the medium of this system, that the sympathy (as this expression is usually understood) between different and distant organs is maintained. Custom, Functions.

[3] Cloquet. [4] Swan. [5] That is, none have been discovered.

however, and the absence of a term sufficiently comprehensive and more expressive of function, require that the title 'sympathetic' should still be retained as applicable to the division of the nervous system under consideration[1].

The nerves derived from the sympathetic ganglia possess the following properties:

1. They are the source of the irritability upon which the action of the purely involuntary muscles depends; such as the heart and arteries, &c.[2].

2. They have under their immediate control the organs of secretion[3]; and govern the vessels which carry on the processes of deposition and absorption; and thus direct nutrition, growth, and decay.

[1] The term 'vegetative,' employed by the Germans, would be less objectionable, as partly indicative of function.

[2] "The great sympathetic bears a strict relation in its development, to the activity and force of circulation in the four classes of Vertebrata, in whom alone a red-blooded circulation exists." (Parker's Lectures on Compar. Anat.—Med. Gaz. vol. vii. p. 67.)

[3] The result of his numerous experiments, to ascertain the influence of the sympathetic system over the secretions and exhalations, is thus stated by a French physiologist: "The parotid glands secrete saliva after section of the facial nerve. The mucous tissues of the lungs, stomach, intestines, &c. possess the power of secretion, although cut off from the cerebral influence by the section of the eighth pair: the testicles secrete semen in the paralysed, and in animals after division of the spinal marrow; and the secretion of the urine is also under the direct influence of the sympathetic." Further, he adds, "the exhalations are equally under the direction of the same system."—*Fonctions du Système Nerveux Ganglionaire*, par J. L. Brachet, 1834, pp. 284, 285.

3. They possess some influence in the changes of the blood from venous to arterial, and the contrary; and in the production of animal heat.

4. By their universal distribution, and free communication with the cerebro-spinal and true spinal nerves, a sympathy is maintained between these distinct systems, and the cooperation of the different organs composing the frame is thus insured; the result of such cooperation being the continuance of life[4].

Distinctive differences.

In short, the distinctive differences between this system and the cerebro-spinal are, that "manifestations essentially vital" are the result of the influence of the former, whilst "the animal and voluntary operations" are presided over by the latter[5].

Pathology of sympathetic.

With respect to the pathology of the sympathetic system, but little is clearly understood. Its derangements are judged of by what we suppose to be its functions; and the remedies which

[4] It has been questioned whether the sympathetic ganglia and their branches may not be made media for the transmission of impressions to the sensorium. The sensation produced by injury to the semilunar ganglion, lesion of the testicle, &c. have been brought forward in support of an affirmative answer to this query. Flourens gives as the result of his experiments, "that the semilunar ganglion is constantly and very energetically excitable; the other ganglia are only so occasionally and in a very slight degree."—*Fonctions du Système Nerveux*, p. 207.

[5] This was the opinion of Bichat, who regarded the ganglia as so many centres of nervous influence superintending the different organic functions.—*Anatomie Générale*, tome 1.

we apply to act on the circulating and secreting systems must surely operate through the medium of the sympathetic nerves, which thus evince a capability of being influenced by external agents, in the same manner as the voluntary nerves.

Further, to quote the words of Professor Müller, "If we only consider for a moment the infinite number of blood-vessels, we may form some idea of the infinite number of the smallest twigs of the sympathetic in all organs. Not only the brain and spinal marrow, but the vital condition of all organs react on the sympathetic through these twigs accompanying the blood-vessels. The source of the heart's perpetual contraction is therefore, *primo loco*, the motor power of the sympathetic. But the cause of the preservation of the latter, and of its excitement, is not only the brain and spinal marrow, but is probably the vital stimuli of all organs which react on the central parts of the sympathetic by means of the nervous twigs accompanying the blood-vessels. The changes which the finest twigs of the sympathetic in any part suffer from acute local disease, and the reaction of these changes on the central portion of the sympathetic, the nerves of the heart and plexus, as well as on the brain and spinal marrow, appear to play a chief part in that set of phenomena which we call fever[1]."

[1] *Handbuch der Physiologie des Menschen*, von Prof. Müller in Berlin, 1835, vol. i. p. 188.

As to the effects of any injury done to the ganglia, which is more in point here, we find them in many respects analogous to those attending injury to the brain. "If," remarks Dr. Copland, "violent blows or contusions in the epigastric region do not immediately destroy the individual subjected to them, they depress in a very remarkable manner the vital energies of the system: the animal heat is uncommonly diminished; the surface is pale and cold; the pulse slow and scarcely perceptible; and the breathing feeble and very slow." Thus we trace the analogy which exists between concussion of the semilunar ganglion and concussion of the brain. "In the former, the vital or organic actions are either exhausted or destroyed; in the latter, the animal or voluntary operations only are suspended[2]." Injury to ganglia.

It were worse than useless to enter upon the discussions as to the (so-called) origin of the sympathetic. It is but a dispute about words to say whether it arises from the fifth and sixth nerves, or from any other point of its numerous con-

[2] Appendix to the Translation of Richerand's Physiology. In the course of the description, short remarks will be made upon the distribution and probable properties of individual parts of the system. There are many works which the reader may consult with advantage, for information on the subject under consideration. He is more particularly recommended to peruse the works of Bichat, Brachet, and Lobstein, in which will be found the most recent opinions and surmises, and the facts on which they are founded.

nexions; and can lead to no useful results either in a scientific or practical point of view. Let us study the system as we find it, viz. a series of ganglia placed in the head, chest and abdomen, giving off nerves which terminate in one of three ways; either by distribution to the organs whose functions they are destined to control, by communication with others of their own system, or lastly, with nerves of the cerebro-spinal system.

OPHTHALMIC GANGLION[1].

Ophthalmic ganglion.

Small and irregular in form; situated between the optic nerve internally, and the abductor muscle of the eye externally. It is immersed in fat, for a granule of which it may be mistaken.

Communications.

From its *posterior* part two branches of communication pass off; the superior to the nasal branch of the ophthalmic division of the fifth pair, as it is lying upon the optic nerve: the inferior to the inferior oblique filament of the common oculo-muscular nerve[2].

Anteriorly, the lenticular ganglion gives off its ciliary filaments, which are divided into three fasciculi: the superior set consists of three filaments; the inferior of six or eight; the internal

[1] Also named 'lenticular'.

[2] By these branches some describe this ganglion as being formed.

of two or three which are derived directly from the nasal nerve. Some of these branches bifurcate soon after their origin, and filaments wind beneath the optic nerve: the whole pass forwards around this nerve, in company with the ciliary arteries, and pierce the sclerotic membrane obliquely. They then assume a flattened form, and become, in their passage towards the ciliary circle, closely adapted to the sclerotic, and have but little connexion to the choroid coat: in this course also they communicate with each other. Branches.

The ciliary nerves terminate in the ciliary circle or ganglion[3], from which several small filaments pass immediately to the iris, to which they are distributed. Distribution.

The *communication* between the ophthalmic ganglion and the rest of the sympathetic, is through the medium of one of the ascending branches of the superior cervical ganglion, which passes up with the carotid artery to the cavernous sinus, and there communicates with the nasal nerve.

Function. The ciliary nerves control the action of the iris. This is, however, only through the medium of the impression made upon the retina; therefore, we find in severe concussion or Function.

[3] This, it will be remembered, corresponds to the junction of the cornea with the sclerotic, and of the choroid with the iris. It is generally considered to consist in part of a true ganglionic structure, though described also as a ligament.

compression of the brain, when the retina is rendered insensible to the stimulus of light, that the iris is in like manner paralysed, and the pupil remains in a fixedly contracted or dilated state.

SPHENO-PALATINE GANGLION[1].

Meckel's ganglion. Situated deeply in the pterygo-maxillary fossa, this ganglion is surrounded by fat and the branches of the internal maxillary artery. Its

Situation. *boundaries* are, anteriorly, the tuberosity of the superior maxillary bone; posteriorly, the pterygoid processes of the sphenoid bone; internally, the nasal plate of the palate bone and spheno-palatine foramen. Its *branches* are superior, inferior, internal, and posterior.

Branches. The *superior* are branches of communication: they consist of two small filaments which ascend to join the superior maxillary division of the fifth nerve, whilst it is crossing the spheno-maxillary fossa.

The *inferior* is the palatine nerve. This descends through the posterior palatine foramen, to terminate in the arch of the palate. In its course it gives off a nasal branch, which passes inwards through a foramen in the nasal plate of the palate bone, and is distributed to the mucous membrane between the middle and inferior turbinated bones. On examining the dry bone, other foramina will

[1] Or, ganglion of Meckel.

be observed communicating with the posterior palatine foramen; these transmit filaments to the velum: other filaments supply the uvula and tonsil. The terminating branches of the palatine nerve, after issuing from the foramen, arch forwards, and are distributed to the palate and gums.

The *internal* are the spheno-palatine branches, four or five in number. They pass from the ganglion directly inwards through the spheno-palatine foramen, which is situated opposite the posterior extremity of the middle turbinated bone. Having arrived at the upper and back part of the nasal fossa, most of these branches terminate by being distributed to the pituitary membrane of the turbinated bones. One remarkable filament, the *naso-palatine*, crosses the nasal arch, to the septum nasi, along which it is continued to the anterior palatine foramen: it descends through this, and joins the *naso-palatine ganglion*. This small ganglion, which was first described by Cloquet, is situated in the common anterior palatine foramen, or foramen incisivum: it receives the two naso-palatine nerves, and gives off filaments to the membrane of the palate, which anastomose with the proper palatine nerve[2].

Naso-palatine ganglion.

The *posterior* branch is the Vidian or recurrent pterygoid nerve: this passes horizontally back-

[2] Knox's Cloquet, p. 521.

wards, and soon enters the pterygoid foramen situated at the root of the processes of that name; and after emerging from this foramen it divides into two filaments, previous to which, however, ramifications are described as passing to the sphenoidal sinus, nasal fossæ, pharynx, and Eustachian tube. Of the two *terminating* filaments, the inferior enters the cavernous sinus by the carotid canal, and there joins the carotid plexus (See *Superior cervical ganglion*): the superior ascends through the foramen lacerum basis cranii anterius; it takes its course backwards and outwards, lying in the groove on the superior surface of the petrous bone, and covered by dura mater and the inferior maxillary division of the fifth nerve: it then enters the aqueduct of Fallopius by the hiatus of the same name, and comes in contact with the facial nerve, which it accompanies, being attached to its inferior surface: opposite the pyramid it quits the portio dura, and enters the tympanum by a foramen proper to itself.

Corda tympani.

Under the name of corda tympani, it crosses this cavity from behind forwards, passing between the handle of the malleus and long leg of the incus; in this situation it is easily exposed, by making a section with a chisel. It then quits the tympanum by the glenoid fissure, in company with the laxator tympani tendon, and descending forwards and inwards, soon joins the lingual-gustatory nerve at an acute angle, and accompanies it to the posterior margin of the submaxillary gland: here they separate, and the corda tympani terminates in a small ganglionic enlargement, the *submaxillary ganglion*, which receives a reinforcement from the gustatory nerve, and gives off filaments that form a plexus to supply the gland. Submaxillary ganglion.

The *communication* between Meckel's ganglion and the rest of the sympathetic is through the medium of the inferior branch of the Vidian nerve, which joins the carotid plexus of the superior cervical ganglion[1].

It is not supposed that any communication, by interchange of filaments, takes place between the corda tympani and facial nerves; the former appears to be merely applied on the latter.

Function. The branches above enumerated are distributed over a large surface of mucous membrane: their function is probably to endow it, as well as the submaxillary gland, with the property of secreting.

OTIC GANGLION[2].

The *Otic Ganglion* is situated to the inner side

[1] "In one subject I traced a very distinct nerve, passing upwards from the spheno-palatine to the lenticular ganglion; but whether this be constant I cannot at present determine." —*Swan, Med. Gaz.*, vol. xiv. p. 848.

[2] This ganglion was first described by Dr. Arnold, of Heidelberg, and the description is extracted from his work entitled *Der Kopftheil des vegetativen Nervensystems beim Menschen*, &c.; 8vo, 1831.

of the third division of the fifth pair of nerves, immediately below the foramen ovale in the sphenoid bone. Its branches are the following:

Branches.

1. branch to the tensor palati muscle; 2. small superficial petrous branch, which penetrates this portion of the temporal bone by a small canal; 3. a communication with the sympathetic filaments surrounding the external carotid and middle meningeal arteries; 4. branch to the tensor tympani muscle; 5. branch of communication to a temporal filament of the third division of the fifth; 6. branch to the internal pterygoid muscle.

Function. "Thus," says Dr. Arnold, "this ganglion is the central organ for the automatous motion of the membrana tympani." "And I have arrived at the conclusion," he afterwards adds, "that the otic ganglion is only found in those animals who possess a tensor tympani muscle[1]."

Cervical ganglia.

The cervical ganglia are three in number,—

[1] Work above quoted, p. 174. Professor Mayo states, that in his dissection of this ganglion he found a plexus of branches communicating with the corda tympani. The otic ganglion is rendered more interesting from its analogy to the ophthalmic ganglion, holding, as the discoverer remarks, the same relation to the organ of hearing as the latter does to the organ of sight. It should be added, that all anatomists have not been equally successful in finding this ganglion. Bock has searched for it in vain, and Prof. Schlemm, of Berlin, traces the branches from the fifth nerve, and thinks a lymphatic gland may have been mistaken for the ganglion. See Hildebrandt's *Handbuch der Anatomie des Menschen,* 1831, vol. iii. p. 458. I have preferred giving the description of Arnold: my own dissections have not been sufficiently satisfactory.

superior, middle, and inferior. Not infrequently the middle is wanting.

SUPERIOR CERVICAL GANGLION.

This is the largest of the cervical ganglia, and never absent. Regular in form, though varying in extent in different individuals, its *shape* is fusiform, or an elongated oval, tapering above and below. Its usual extent is from the inferior margin of the first cervical vertebra to the transverse process of the third. It *lies on* the rectus capitis anticus major muscle; it is *covered* by the internal carotid artery; the external carotid artery, jugular vein, pneumogastric and lingual-motor nerves, must be raised in order to expose it. The principal varieties in this ganglion, as remarked by Cloquet, are, that its volume is dependent on its length, the former decreasing in proportion to the increase of the latter; that it is occasionally contracted in its centre, and sometimes cylindrical. Its branches are ascending, descending, anterior, external, and internal. Description. Branches.

The *ascending* branches are two in number, and accompany the internal carotid artery: by their subdivision and reunion, the carotid plexus is formed in the canal of that name: the filaments derived from this plexus communicate with the following nerves; the Vidian, nasal branch of the fifth, and abducens or sixth cerebral nerve. A small ganglion is described as sometimes existing in this Ascending.

plexus in the cavernous sinus, the *cavernous ganglion*[1]. The terminating filaments accompany the branches of the internal carotid artery; and on the anterior communicating artery of the brain, another very small *ganglion* has been described by *Ribes*: this anatomist has also described a filament which he traced along the central artery of the optic nerve, and which, he thinks it probable, forms a communication between the retina and superior cervical ganglion[2].

Descending. The *descending branch* is continued downwards from the inferior contracted extremity of the ganglion, lying in its course between the rectus capitis anticus muscle and the carotid sheath: it terminates in the middle ganglion of the neck, or, if that be wanting, in the inferior. This branch receives filaments of communication from the cervical plexus, and gives off two or three which assist in forming the cardiac plexus[3].

Anterior. The *anterior branches* consist of communicating filaments to the facial, pneumogastric, glosso-pharyngeal, and lingual motor nerves; and other filaments descend around the common carotid artery, which they supply: lastly, a third set, which are minute, numerous, and plexiform, accompany

[1] Knox's Cloquet, p. 520.

[2] Ribes, *Mém. de la Société Médic. d'Emulat.*, tom. vii. p. 97. (quoted from Cloquet.)

[3] The course and distribution of the cardiac nerves are better described separately; they will be found to succeed the cervical ganglia.

the different branches of the external carotid artery, along which they may be traced for some distance.

The *external branches* are short, but of considerable size; they cross the rectus anticus muscle, and communicate with the anterior branches of the four first cervical nerves. External.

The *internal branches* are very variable; they incline inwards; some pass to the anterior cervical muscles, others to the pharynx and larynx, communicating with the pharyngeal plexus and laryngeal nerves. Internal.

MIDDLE CERVICAL GANGLION.

This ganglion is frequently altogether wanting, and when present is irregular in position, form, and size. It is usually found opposite the body of the fifth cervical vertebra, and of a rounded form, covered by the carotid sheath, and lying upon the longus colli muscle, near the arch of the inferior thyroid artery.

Branches. Its upper margin receives the descending branch of the superior ganglion: from its inferior border proceed four or five filaments, which descend on either surface of the subclavian artery, and join the inferior cervical ganglion; anteriorly, it gives off the middle cardiac nerve; externally, filaments of communication pass to the fifth and sixth cervical nerves; the internal filaments accompany the thyroid artery, and are dis- Branches.

tributed to the gland of that name, the trachea, and œsophagus, and communicate with the inferior laryngeal nerve[1].

INFERIOR CERVICAL GANGLION.

Lowest ganglion of the neck.

This ganglion is regular in existence, but irregular in form and size; it is occasionally continuous with the last described, but more frequently with the first thoracic ganglion. Its situation is between the transverse process of the last cervical vertebra and the neck of the first rib; and it is usually in part concealed by the vertebral artery. Its branches are divisible like those of the preceding.

Branches.

Branches. Superiorly, it receives the communicating filaments from the middle ganglion of the neck, and sends off *ascending* branches which accompany the vertebral artery in its course, and give filaments of communication to the cervical nerves. Its *descending* filaments usually encircle the subclavian artery, and communicate with the first thoracic ganglion. The *internal* filaments communicate with the pulmonary plexus[2]. The *external* filaments communicate usually with the anterior branches of the two last cervical nerves: others accompany the internal mammary and sca-

[1] Also with the phrenic nerve, according to Cloquet, p. 526.

[2] Also with the phrenic and recurrent laryngeal nerves, according to Cloquet, p. 527.

pular branches of the subclavian artery. The *anterior* filaments form the inferior cardiac nerve.

Remarks. We find the general destination of the branches of the cervical ganglia to be, for communication or distribution: by the branches of the former order we have the connexion established between many of the cerebral nerves or their branches, and the cervical nerves, and between the different ganglia; as well as contributions sent to some of the plexus: the filaments of the latter order are less numerous, and find their way principally to the thyroid gland, œsophagus and air-tube, and anterior cervical muscles. Though interesting in a physiological point of view, these ganglia and their branches do not offer room for many surgical observations. Their position with respect to the carotid sheath should not be lost sight of in passing a ligature round this vessel; and whilst care is taken to avoid the other nerves in the proximity of the artery, the operator should be mindful to pass the aneurism needle as close as possible to the vessel in question, to avoid including any part of the sympathetic. The vascular filaments are numerous and of considerable size, particularly those which accompany the internal carotid: would not this seem to imply that the property of active contractility is resident in arteries? at any rate it is a fact which favours the opinion, if it be allowed that involuntary muscular action is under the Remarks.

control of the sympathetic; for the brain is an organ, whose activity is dependent to so great an extent on the vigour of the circulation, and whose vessels are so largely supplied from this nervous source.

CARDIAC NERVES AND PLEXUS.

Cardiac nerves. These branches and the resulting plexus require a careful dissection. The cardiac nerves are three in number on either side; superior, middle and inferior: the corresponding branches are not symmetrical.

Superior. Right nerve. The *superior cardiac* nerve on the *right* side arises by several filaments from the superior cervical ganglion and branch of communication between it and the middle: it descends behind the common carotid artery, and by the side of the trachea, and enters the chest between the subclavian vein and bifurcation of the arteria innominata: it here communicates with the other cardiac nerves and recurrent laryngeal; the principal filaments passing along the innominata to the aorta, where they join the cardiac plexus. In this course, the right superior cardiac nerve *communicates* with the pharyngeal and inferior thyroid plexus; also with the pneumogastric, laryngeal and descendens lingualis nerves.

Left nerve. The superior cardiac nerve on the *left* side takes a deeper course between the subclavian and carotid arteries: on arriving at the arch of the aorta, it divides into anterior and posterior filaments; the former communicate with the cardiac filaments of the pneumogastric, the latter join the cardiac plexus.

The *middle cardiac* nerve on the *right* side is larger than the other two. It arises by several filaments from the middle cervical ganglion, or if that be not present, from the communicating cord between the superior and inferior ganglia: it descends on the posterior and inner aspect of the common carotid, and enters the chest anterior to the subclavian artery; and is thence guided by the innominata to the aortic arch, between which and the trachea it joins the cardiac plexus. In this course it *communicates* with the pneumogastric, recurrent laryngeal, and inferior cardiac nerves. Middle right nerve.

The middle cardiac nerve of the *left* side is frequently derived from the inferior ganglion, or has its place supplied by an inferior cardiac nerve of greater size. Left nerve.

The *inferior cardiac* nerve is formed by several filaments derived from the inferior cervical ganglion. Inferior. That of the *right* side, after passing behind the subclavian artery, where it is close to the recurrent nerve, glides along the innominata to the aorta. Right nerve. On the *left* side, this nerve, which is usually large for the reason above assigned, runs parallel to the subclavian artery. Left nerve. Both terminate in the cardiac plexus, anterior to the arch of the aorta.

THE CARDIAC PLEXUS OR GANGLION.

Plexus of the heart.

This consists of an intricate interlacement of small nervous filaments, inclosing several small ganglia, which give it a grey colour and soft consistence; hence it is styled *ganglion*. Its *situation* is between the aortic arch and tracheal bifurcation, extending as high as the origin of the innominata, and as low as the division of the pulmonary artery. This great plexus, which is formed by the cardiac nerves entering it as already described, receives communicating filaments from the pneumogastric nerves[1], and divides into various secondary plexus.

Secondary plexus.

Posteriorly, some filaments of communication encircle the ductus arteriosus, and descend along the pulmonary vessels to the plexus of that name: others accompany the right or posterior coronary artery, and forming a plexus around it, are distributed with its branches to the structure of the heart.

The *anterior* cardiac plexus is formed by branches which wind round the aorta, and receives the inferior cardiac nerve as before mentioned: this plexus accompanies the left or anterior coronary artery, and is distributed to the convex surface of the heart[2].

[1] See the Pneumogastric nerves.

[2] For remarks on these plexus, the reader is referred to the observations following the thoracic ganglia, and eighth pair of nerves.

THE THORACIC GANGLIA.

These are *twelve* in number on either side; except in those cases in which the first thoracic ganglion forms a part of the inferior cervical; in such instances there are, of course, but eleven pairs, although, at any rate, the first pair is usually the largest. They are generally described as triangular, with an angle facing outwards; but they are frequently irregular in form, or elongated from above downwards, being in *shape* and *size* like barley-grains. They are symmetrical and placed in the same line: their *situation* is on the head of each rib or in the intercostal space, and covered by the costal pleura. Their branches may be divided into communicating and splanchnic.

Form.

The *communicating* branches consist of, 1. the connecting cord between each two ganglia, which is prolonged from the tapering lower extremity of the one, to the upper extremity of that below, crossing the intercostal vessels; these are not very regular in size; the last pair of thoracic communicate with the first pair of lumbar ganglia, the connecting filaments entering the abdomen beneath the true ligamentum arcuatum: 2. one or more filaments which proceed upwards and outwards, and communicate with the intercostal nerves just as they quit the intervertebral

Division of branches.

foramina[1]: 3. several fine filaments which pass forwards and inwards to the posterior mediastinum, and terminate by communicating with the pneumogastric in the pulmonary plexus: some of these filaments may be occasionally traced downwards along the aorta, till they join the cœliac plexus. The splanchnic nerves are two on each side; great and small.

GREAT SPLANCHNIC NERVES.

Origin. Each *arises* by four or five distinct filaments of considerable size, which are derived from the inner sides of the thoracic ganglia, from the sixth to the ninth or tenth inclusive. After a very oblique course downwards and inwards, during which they rest on the sides of the vertebral column, they terminate by uniting into one cord on the side of the body of the tenth or eleventh dorsal vertebra. The great splanchnic trunk being thus formed, enters the abdomen by passing through the crura of the diaphragm, either in company with the aorta, or, as is more usually the case, separated by a few muscular fibres from this vessel: it then joins the semilunar ganglion.

SMALL SPLANCHNIC NERVES.

These nerves are much smaller than the last. Origin. Each arises by two roots which are derived from

[1] See Spinal nerves—Anterior dorsal trunks.

the tenth and eleventh thoracic ganglia, or occasionally from the eleventh and twelfth[2]: these unite on the last dorsal vertebra, and the trunk pierces the diaphragm external to the last-described. This nerve sends an ascending communicating branch to the great splanchnic; and after giving a few filaments of communication to the solar plexus, it joins the renal plexus.

Remarks. We have thus remarked that the heart is largely supplied from the sympathetic ganglia; and if the hypothesis already alluded to, respecting the function of the sympathetic, be correct[3], this organ, as a purely involuntary muscle, is dependent upon this nervous source for its muscular irritability; and its membranes are moreover endowed with the property of secreting: whilst the sympathy between it and other organs is referable to the cerebro-spinal nerves[4]. It will, moreover, be found in a future dissection[5], that the lungs also receive in part their supply from the sympathetic; the property of secretion is thus bestowed on their mucous and serous membranes; and the process of decarbonization Remarks.

[2] The usual destination of the descending filament or filaments from the twelfth thoracic ganglion, is to the semilunar and first lumbar ganglia; and generally communicating with the renal plexus.

[3] That it presides over all the purely involuntary muscles. See remarks at the commencement of this system.

[4] See the remarks attached to the eighth pair.

[5] See the Pneumogastric nerves—Pulmonic plexus.

of the blood is, doubtless, thus in some way influenced. It is difficult to say whether the large and regular branches of communication to the intercostal nerves be for the purpose of controling, in some degree, muscular action: it is not impossible, as the muscles supplied are those of ordinary inspiration.

GANGLIA BELOW THE DIAPHRAGM.

These ganglia may be classed thus; proper abdominal or semilunar ganglia, a pair; various small ganglia contained in the renal and secondary divisions of the solar plexus; lumbar ganglia, usually five pairs; sacral ganglia, usually four pairs; an azygos coccygeal ganglion.

THE SEMILUNAR GANGLIA.

Abdominal ganglia.

Form, size, &c.

These, which are two in number, are the largest pair of ganglia found in the sympathetic system, or, indeed, in the body. They are not usually similarly proportioned: in *form* they are somewhat flattened and irregularly semilunar, with their convexity facing downwards and from the median line: their *bulk* is about equal to a horse-bean: as to *situation*, they rest upon the crura of the diaphragm immediately above the renal arteries, and against the aorta, opposite the origin of the cœliac axis. So much for the general description; each ganglion, however, requires a separate notice.

That of the *right* side is almost invariably the larger, and not infrequently presents the appearance of two smaller ganglia united: it is covered by the vena cava, and lies close to the head of the pancreas: the right renal capsule extends above it, and is sometimes in contact with it. Peculiarities of each ganglion.

The *left* ganglion is covered by the tail of the pancreas and the splenic vessels; and on this side, the renal capsule being situated higher than on the right, it is not in contact with the corresponding ganglion.

In the upper portion of these ganglia the great splanchnic nerves terminate; and they are connected together by means of short but thick filaments or bundles of filaments, which have, commonly, very much the same appearance and consistence as the ganglionic structure itself[1]. Various other filaments are passing off in every direction from each ganglion, forming by their interlacement with each other a complete network, in the meshes of which, small ganglionic enlargements may be perceived at various points: to this nervous network, the title of solar plexus has been given. Connexions.

SOLAR PLEXUS.

This is a plexus of considerable *extent*, but very irregular form: it lies upon the crura of the

[1] Cloquet notices that this connexion is such as to form, frequently, but a single ganglion.

diaphragm and across the aorta, under cover of the stomach and liver, and extends as low as the pancreas. It communicates with the last thoracic ganglion; and several filaments may be traced from the right or posterior pneumogastric trunk into this plexus, the left nerve furnishing comparatively few. The solar plexus divides into various secondary plexus, which are distinguished by the same names as the arteries with which they are distributed, viz. phrenic; cœliac, subdividing into gastric, hepatic and splenic; superior mesenteric; inferior mesenteric.

Division of plexus.

PHRENIC PLEXUS.

Phrenic.

This name is applied to a few filaments which accompany the phrenic arteries in their distribution to the diaphragm: some of these may be traced to communicate with the proper phrenic nerves[1].

CŒLIAC PLEXUS[2].

Cœliac.

By the cœliac plexus is meant, that contracted portion of the solar plexus which immediately surrounds the arterial axis of the same name: it contains several small ganglia, and receives filaments of communication from both phrenic and

[1] It is very problematical whether these filaments of the sympathetic at all control the action of the diaphragm.

[2] Solar and cœliac plexus are frequently applied synonymously: this is not altogether incorrect, as the latter is only the prolongation of the former.

pneumogastric nerves. It soon subdivides into its three secondary plexus. Subdivision.

GASTRIC PLEXUS.

This plexus surrounds the artery of the same name, and accompanies it along the small curvature of the stomach and through its course, sending off filaments wherever the vessel gives a branch. It *communicates* with the hepatic plexus, and freely with the pneumogastric nerves. Gastric.

HEPATIC PLEXUS.

This large plexus receives considerable filaments from the right, and some from the left pneumogastric nerve[3]. A division of the plexus accompanies the right gastro-epiploic artery in its course and distribution to the stomach, pancreas and duodenum; thus communicating freely with the gastric plexus. The principal portion of the hepatic plexus enters the transverse fissure of the liver, and accompanies the vessels and duct into the substance of this organ[4]. Hepatic.

SPLENIC PLEXUS.

The smallest of the three plexus; this takes the course of the splenic artery, giving filaments Splenic.

[3] See Swan's Plates of the Nerves, p. 23.

[4] In the fœtus, some filaments of this portion of the plexus are united to the umbilical vein, and accompany it to the placenta. (Cloquet's Anatomy, p. 535.)

with its branches to the pancreas, &c.: the rest enter the spleen. Each of these secondary plexus present ganglia among their filaments.

SUPERIOR MESENTERIC PLEXUS.

Superior mesenteric.

This is the prolongation of the solar plexus, which, descending in front of the aorta, surrounds the superior mesenteric artery at its origin. It will be remembered that the course of this artery lies behind the pancreas and across the inferior transverse portion of the duodenum, subsequently taking an arched direction between the layers of the mesentery towards the right iliac fossa; and that its branches are a few small ones to the pancreas and duodenum, from its concavity the three colic branches, and from the convexity of its arch, several large ones to the small intestines. Through this course and in its distribution it is accompanied by the superior mesenteric plexus. The ganglia of this plexus are numerous, and, as observed by Cloquet, especially seen on the edge of the intestine.

Distribution.

INFERIOR MESENTERIC PLEXUS.

Inferior mesenteric.

After the formation of the last plexus, the branches which are found descending on the aorta are far less numerous, but become reinforced by filaments of communication received from the lumbar ganglia and from the renal plexus, as the origin of the renal vessels is crossed.

The principal portion of this plexus is distributed, in company with the three branches of the inferior mesenteric artery, to the sigmoid flexure of the colon and to the rectum: communicating with the hypogastric plexus by filaments which descend into the pelvis with the internal iliac artery. Filaments have been traced along the external iliac artery even to the upper part of the thigh[1]. This plexus presents but few, if any, ganglia. Distribution.

RENAL PLEXUS.

These plexus are two in number; one situated opposite each renal artery. They are in part formed by an offset of filaments from the semilunar ganglia, but principally by receiving the small splanchnic nerves: they are, moreover, joined by communicating filaments from the last thoracic and one or two lumbar ganglia. After giving off the two following secondary plexus, they penetrate the kidneys along with the vessels, and are distributed to it. A few ganglia are found in these plexus, previous to their entering the kidneys. Renal. Subdivision.

SUPRA-RENAL PLEXUS.

These are a pair, and consist of filaments de- Supra-renal.

[1] Knox's Cloquet, p. 537. I have remarked that young strumous, or anasarcous subjects are the best adapted for the dissection of the abdominal plexus; the nerves being, in them, large and white.

rived from the last-described, which accompany the supra-renal arteries to the organs of that name.

SPERMATIC PLEXUS.

Spermatic. These are also a pair, and are likewise derived from the renal plexus. They accompany the spermatic vessels, and their destination is to the testicle in the male, and the ovary in the female[1]. They present a few small ganglia, and in their course give filaments to the ureter.

LUMBAR GANGLIA.

Lumbar. These are variable both in number and size, consisting, as before stated, usually of five pairs, but sometimes as few as three; their *bulk* is about equal to that of a barleycorn, though in this respect not always symmetrical on both sides; and their *form*, an elongated oval. They are situated on the sides of the bodies of the lumbar vertebræ, resting on the inner margin of the psoas magnus muscle, and near the origin of the lumbar arteries. Those of the left side are under cover of the aorta, and those of the right, beneath the vena cava. Branches. The filaments derived from these ganglia are, communicating and aortic.

The *communicating* filaments are, 1. the connecting cord between the different ganglia, the

[1] It is impossible to say with certainty whether they penetrate these organs. (Cloquet, p. 538.)

first pair receiving from the last thoracic ganglion, filaments which enter the abdomen beneath the true ligamentum arcuatum[2], and the last pair in like manner giving filaments to the first sacral ganglia: 2. filaments pass outwards to communicate with the anterior branches of the lumbar nerves as they quit the intervertebral foramina. The *aortic* branches, which present small ganglia, pass before the abdominal aorta, and some few behind, and communicate with all the abdominal plexus before mentioned. Some filaments descend to the hypogastric plexus.

SACRAL GANGLIA.

These also are variable in number, form, and size, being either three or four pairs, and *situated* opposite or near the anterior sacral foramina, close to the lateral sacral arteries; the inferior ganglia are, consequently, nearer the median line than the superior. They have filaments of communication with each other, with their fellows, and with the anterior branches of the sacral nerves: the upper pair receive filaments from the last pair of lumbar ganglia, and the inferior are connected to the coccygeal ganglion. The anterior filaments of the sacral ganglia assist in forming the following plexus. Sacral branches.

[2] This, it will be remembered, stretches between the transverse process of the first and body of the second lumbar vertebra.

HYPOGASTRIC PLEXUS.

Hypogastric.

This is a network of nerves on each side, surrounding the internal iliac arteries, and made up from the following sources: filaments from the sacral ganglia, from the combination of the mesenteric and aortic plexus, and from the visceral branches of the sciatic plexus[1]. This plexus, presenting few if any ganglia, accompanies and is distributed with the branches of the internal iliac artery to the different pelvic viscera. Filaments also may be traced accompanying the glutæal and sciatic vessels out of the pelvis[2].

COCCYGEAL GANGLION.

Coccygeal.

This is a solitary ganglion (*Ganglion impar*): it is usually semilunar, receiving at its cornua the coalescing filaments from the last pair of sacral ganglia: it gives filaments from its convexity, which are lost on the coccyx.

[1] It is important to recollect that a large proportion of spinal nerves assist in forming this plexus; for there are organs, under the control of the will, to be supplied. See Sacral nerves —Sciatic plexus.

[2] Professor Müller describes a plexus, giving off grey filaments to the cavernous structure of the penis. This plexus is situated on either side of the prostate gland and membranous portion of the urethra, connected to either hypogastric plexus, and communicating with the proper pudic branches. Several ganglia are found in it: its filaments pass with the vessels into the structure of the cavernous body of the penis. The Professor believes that on them the phenomena of erection depend. (Medical Gazette for April 23, 1836.)

REMARKS.

In the two divisions of the great compartment which contains the chylopoietic and urinary viscera, the branches of the sympathetic are on a large scale and universally distributed. We will briefly notice their influence over the various organs they supply. Physiology.

Some few filaments pass to the *diaphragm*: it is improbable that these have anything to do with the action of this muscle. As before explained[3], the impression made upon the pneumogastrics by the presence of carbonic acid in the lungs (or whatever the cause may be) must be first conveyed to the brain, and then the mandate issued through the medium of the phrenics to the diaphragm. It may be noticed, however, that a galvanic shock passed through the semilunar ganglion produced irregular contractions of the diaphragm[4]; and the temporary suspension of respiration is a well-known effect of a blow in the epigastrium[5]. Diaphragm.

[3] See Physiological remarks attached to the Brain. Also Phrenic and Pneumogastric nerves.

[4] Dr. Copland's Experiments.

[5] That the branches from the ganglion or the surrounding tissues served as conductors of the electricity to the phrenic nerves is a sufficient explanation of the former phenomenon. In the latter, interruption of a vital function might well be expected from injury to so vital a part, though no immediate connexion existed.

Liver, &c.

Of the *glandular* viscera connected with digestion, we find the liver and pancreas receiving a copious supply of nerves from the sympathetic system for the purposes of secretion; and whatever the functions of the spleen may be, they are, no doubt, under the control of the same system. With respect to the *membranous* digestive viscera, they are not so easily disposed of. Their secreting properties are no doubt derived from the same source; but is the irritability of their muscular coat dependent on the influence of this system, and how far?

Membranous viscera.

No part of the alimentary canal, if we except possibly the stomach and lower portion of the rectum[1], is under the influence of the will; and

[1] This, however, is questionable. In speaking of the rectum as possibly influenced in part by the will, allusion is made more particularly to the lower part of this gut. I think, in ascribing to the muscle named 'internal sphincter' that action alone which its name denotes, that its use is not sufficiently extended: no doubt it may act in part, though comparatively feebly, as a sphincter, but I have very little question that its principal power is, in common with the other circular muscular fibres of the intestines, to pass onwards the contents of that portion which it surrounds; in short, that its principal action is as an evacuator of the fæces. Moreover, I may mention the following fact in support of the above conjecture, that a great portion of the rectum may be partly dependent on cerebral influence: Having had the whole alimentary canal of a horse removed immediately after death, I have remarked that the activity of peristaltic motion, which was so marked in the small and upper part of the large intestines, gradually decreased so as to be scarcely perceptible in the inferior part of the rectum: when an incision was made, the contents were readily expelled

this alone would incline us to conclude, from analogy, that the power of contraction could not be connected with the voluntary nerves. Neither is this conclusion negatived by the results of experiments, in which the pneumogastric nerves were tied, and the stomach rendered incapable of rejecting its contents, though excited by strong emetics[2]: nor by the well-known fact, that obstinate constipation accompanies paralysis, the result of injury to the spine, &c. These facts only prove, that depriving an organ of its appropriate sensibility, (which is derived from the cerebro-spinal system,) renders it incapable of receiving the impressions necessary for the due performance of its functions[3]. Moreover, as before noticed,

by this action from the former, but the action was incapable of rejecting any portion from the open extremity of the rectum.

[2] Experiments by Dr. Haighton, Mem. of London Med. Soc. Trans., vol. ii. p. 512.

[3] The real explanation most probably is, that the act of vomiting is far less dependent on the muscular contraction of the stomach, than on mechanical compression between the diaphragm and abdominal muscles. The cause of this action must be sought for, as it can only be referable to, the excito-motory circle. If the pneumogastric nerves be divided, the circle is destroyed, and these, the excitor nerves, are no longer capable of conveying the impression of a stimulus from the stomach to the brain: it necessarily results that the brain is incapable of reflecting an influence which it has not received. The experiments of Magendie and others, though not warranting, perhaps, the conclusions which they draw, render it highly probable that the stomach itself performs but a minor part in the *act* of rejecting its contents: it will be remarked, therefore, that this explanation does not interfere with the

the two chains are so linked together, and dependent upon one another for support, that if one be demolished, the other is, at the least, severely shaken. Lastly, there is an objection which equally militates against the opinions that these muscles are controlled by the excito-motory system or cerebro-spinal nerves; it is, that they continue to contract regularly and for a long time, after the brain and spinal cord have been destroyed[1]. The inference therefore is, that the sympathetic system presides over the muscular portion of the membranous chylopoietic viscera; if we except, as before stated, the possible voluntary power possessed by the stomach and a part of the rectum[2].

Urinary organs.

The *kidney*, being a secreting organ, receives its supply in chief from the sympathetic. In the *urinary bladder*, however, we recognise a muscular bag, which is in part under the influence of the will, but which is, moreover, capable of being influenced whilst in a morbidly irritable condition

supposition that the muscular coat of this viscus is controlled by the ganglionic system.

[1] It may be objected to this, that a voluntary muscle will also contract (as in an amputated limb) when cut off from the source of its nervous supply: the cases, however, are by no means identical. In this instance the contractions are irregular and very soon cease, being solely dependent on the local stimulus.

[2] The subject of digestion, and the effect of some poisons on the stomach, is considered under the head of the pneumogastric nerves, to which the reader is referred.

(as in children, or in hysteria,) by the excito-motory system, producing incontinence. This organ therefore is not under the control of the sympathetic; yet it is supplied from the hypogastric plexus. This is true; but be it remembered that this plexus is composed in great measure by filaments from the spinal nerves, and that its ganglia are comparatively few and small. No doubt the influence of the vegetative system is required for the secretion of its mucous membrane; but over its muscular coat it has no control[3].

The *uterus*, with its appendages, also receives its supply from the same source as the bladder, viz. the hypogastric plexus. The mode in which these organs are influenced during conception, generation, and expulsion of the fœtus, is but little understood. The nerves which are distributed to them are more developed during the period of puberty; and Dr. W. Hunter, and, more recently, Professor Tiedemann, have shown that they are increased in size during gestation. It is most probable that the contractile power of the uterus is under the excito-motory system[4]. Uterus.

The *testicles* get branches from the emulgent Testicle.

[3] For further information on this subject, and respecting the action of the sphincters, the reader is referred to a paper of mine in the Medical Gazette, No. for June 18, 1836.

[4] It is a curious fact, that in extra-uterine conception, the uterus contracts at the usual and proper period; this, therefore, cannot be the effect of the stimulus of distention.

plexus: these can be the only nerves which order the secretion of the semen[1].

Arteries.

The *aorta* and large arteries in the abdomen, as elsewhere, get supplied by filaments from the sympathetic ganglia; and it is these branches which it is presumed are continued along the vessels to their terminations[2]. The peritoneum, no doubt, receives an ample supply from the same source, for the purposes of secretion.

SUMMARY VIEW OF THE SYMPATHETIC SYSTEM.

An artificial division of the sympathetic ganglia may be made, as shown below; this, however, is purely arbitrary, and the student is requested not to lose sight of the fact, that the *only* object of such division is to facilitate the remembrance of this somewhat intricate part of anatomy[3].

Arrangement of ganglia.

The arrangement consists in this: that the *three cervical, twelve thoracic, five lumbar, four sacral,* and *one coccygeal* ganglia should be called the *primary* sympathetic ganglia; that the *ophthalmic, spheno-palatine, naso-palatine, submaxillary, ca-*

[1] These are the only nerves which supply the proper structure of the testicle, and it is only surmised that they penetrate its substance. Its envelopes receive filaments from the inguino-cutaneous branches of the lumbar plexus.

[2] May not ganglionic matter be deposited in or between the coats of arteries?

[3] It was originally intended to have added a tabular view of this system, but an attempt to put this into effect, proved that it would confuse rather than elucidate the subject, and the recapitulation which follows has therefore been substituted.

vernous, and *Ribes'* ganglia, in the head, and the *semilunar* ganglia in the abdomen, should be considered as *secondary* ganglia; and that the *ganglia* formed in the meshes of the different plexus, viz. the *cardiac, solar, cœliac, gastric, hepatic, splenic, superior* and *inferior mesenteric, renal, spermatic, aortic,* and *hypogastric,* be classed as *tertiary* ganglia.

Situation of ganglia.

As a consequence of the almost invariable distribution of their filaments in company with arteries, it will be observed that nearly all the ganglia are placed in contact with, or near to some arterial trunk. An attention to this fact will tend to assist the memory; and, in aid of this purpose, a concise review and recapitulation of the whole system may not be deemed superfluous.

RECAPITULATION OF THE PRINCIPAL GANGLIA AND PLEXUS.

Ganglia.

Ophthalmic ganglion. Near the ophthalmic artery; destination of its filaments, to the iris.

Spheno-palatine ganglion. Amid the branches of the internal maxillary artery; destination of its branches, to the nasal fossæ, velum, tonsils, pharynx, palate, gums, and submaxillary gland.

Superior cervical ganglion. Behind the internal carotid artery: large, and important, as forming the medium of communication between the sympathetic and the various cerebral nerves, and the ganglia of the head. The *communicating* filaments from this ganglion are given to many of the cerebral nerves, the anterior cervical nerves, the cardiac and pharyngeal plexus, &c.; whilst the supplying filaments are few in number, viz. to the vessels, pharynx, larynx, and anterior cervical muscles.

Middle cervical ganglion. Near the inferior thyroid artery; communicating with the other cervical ganglia, fifth and sixth cervical, and recurrent laryngeal nerves and cardiac plexus; gives filaments to the thyroid gland, trachea, and œsophagus.

Inferior cervical ganglion. Behind the vertebral artery; communicates with the middle cervical and first thoracic ganglia, pulmonary and cardiac plexus, and cervical nerves; filaments accompany the various branches of the subclavian artery.

Thoracic ganglia. Placed near the intercostal arteries: communications, with one another; with the last cervical and first lumbar ganglia; with the intercostal nerves; with the pulmonary and cœliac plexus; giving filaments from the sixth to the eleventh inclusive, which form the splanchnic nerves.

Semilunar ganglia. On either side of the cœliac axis; receiving the great splanchnic nerves, and communicating with each other and with the solar plexus.

Lumbar ganglia. Near the lumbar arteries:

communicating with each other, the last thoracic and first sacral ganglia, the anterior lumbar nerves, the aortic and hypogastric plexus.

Sacral ganglia. By the side of the lateral sacral arteries: communicating with each other, the last lumbar and coccygeal ganglia, the lumbar nerves, and hypogastric plexus.

Coccygeal ganglion. Opposite the middle sacral artery: communicating with the lower sacral ganglia and nerves.

Cardiac plexus. On the aortic arch: distribution, to the heart and great vessels, and communicating with the pulmonary plexus. Plexus.

Solar plexus. Across the aorta; giving off the following secondary plexus, which are situated opposite the arteries of the same names: *phrenic,* to the diaphragm; *cœliac,* dividing into *gastric,* to the stomach; *hepatic,* to the liver; *splenic,* to the spleen; *superior mesenteric,* to the pancreas, all the small intestines, and arch of the colon; *inferior mesenteric,* to descending portion and sygmoid flexure of the colon, and the rectum.

Renal plexus. To the kidneys; and giving off the *capsular* and *spermatic* plexus.

Hypogastric plexus. Distributed with the branches of the internal iliac artery.

In thus reviewing this division of our subject, Remarks. and without questioning further the appropriateness of the term *sympathetic,* as applied to this system exclusively, we willingly acknowledge the importance of the part it plays in the animal economy, and the perfection that results from the combined influence of this with the other divisions of the nervous system, which is thus the means of associating distant and very different parts of the frame, producing between organs whose offices are so varied, nay, in many instances directly opposed, that harmony which is so essential to the due performance of their functions, and the well-being of the system as a whole; a combination of means which, in its results, whilst a source of wonder and admiration to the contemplative mind, forces from us a reluctant acknowledgment of our ignorance of the mode of applying these means to the required end, and of the darkness in which the subject of nervous influence is involved, even in the comparatively enlightened state of the various branches of medical science in the present day[1].

It is not in points of great import to him as an operator that the surgical anatomist must look to be repaid for his labour in acquiring a thorough knowledge of the sympathetic system of nerves; but it is by putting him in possession of information so essential to him as a scientific surgeon, that he finds a requital for his trouble. His acquired information teaches him to trace to its source, the sympathetic derangement of the functions of

[1] See observations introductory to the Sympathetic System.

distant organs; it teaches him not to be satisfied with treating effects, but to seek for disturbing causes in parts far removed from the apparent seat of mischief. Indeed, this remark is equally applicable to the whole nervous system, and should never be lost sight of in the study of this important and highly interesting department of anatomy.

That the brain and nerves are the seat of what we call 'nervous influence' we know experimentally; and this knowledge is, and probably ever will be, sufficient for most practical purposes: what that *influence* may be, is in the highest degree hypothetical; and here conjecture should cease: to search after that hidden link in Nature's chain which connects the *will* with the *action*, is not within the province of physiology; that connexion is a problem too intricate for Man, in all his pride of intellect, to solve.

THE END.

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