ABSTRACT OF LECTURES ON THE ANATOMY, PHYSIOLOGY, AND ZOOLOGY OF THE CETACEA.

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LECTURE III.

THE largest of all known whales is *Balenoptera Sibbaldii*, which attains the great size of about eighty feet. This is probably the extreme length to which it grows, though greatly exaggerated accounts of its length are often given by travellers and others; but, in those cases, the measurements invariably turn out to have been made only approximately, being frequently estimated in relation to surrounding objects, or in relation to the size of the ship, in instances where the animal has been captured. The exaggerated accounts regarding size holds good not only of this animal, but of many, and indeed all, the large whales. It is a curious fact that in recent times whales have continued to increase in size; none of the extinct species are so large as those which now inhabit the seas. In this respect, they form a marked contrast to many other animals—such, for example, as the amphibia, reptilia, sloths, and birds—the extinct forms of some of which are of enormous size compared with that of those still inhabiting the globe.

The conformation of the parts of the skull about the olfactory region, in *Balenoptera rostrata* and in all the whalebone-whales, is markedly different from what is found in the toothed whales. In the former, there is an immense mass of very cancellous bone, situated between the nasal passage and the brain-cavity, in the centre of which is a distinct olfactory plate; from this a canal extends to the brain-cavity for the passage of the olfactory nerve from the brain to the surface of the plate. This arrangement is absent in the toothed whales. The whalebone-whales are probably able to smell the air they breathe, as it passes into their lungs; though, on account of the olfactory apparatus being feebly developed in these animals, they probably appreciate odours to a less extent than man and many other animals. The cervical region is very short, and there is little or no movement between the individual vertebrae, which may be entirely or partially ankylosed. The bodies of the vertebrae are very thin. The odontoid bone is absent or rudimentary. In the *Balenoptera*, the vertebrae are separate; the atlas is simple, with a small spine. The axis has no odontoid projecting upwards from its body, though the flat smooth portion on the upper surface, to which the check ligaments are attached, is essentially a rudimentary odontoid, as Professor Macalister of Dublin has been able to show from a study of the development of the bone. It has a distinct centre of ossification, and is at an early period separate from the centrum, but soon becomes ankylosed to it. The ossification of the transverse processes takes place from the body outwards. Each transverse process consists of two separate branches in the first instance—the parapophysis and the diapophysis. These are united only at their distal extremities, leaving a large foramen in all but the seventh cervical vertebra, and are directed outwards and backwards. Between these processes, and protected by them, are large plexuses containing arterial blood, which fill up the foramen, and evidently serve as stores for an extra quantity of blood. The dorsal vertebrae are eleven in number in this species, and are simple in character. The lumbar and caudal regions pass gradually into one another; there is no sacrum interposed between them; the anterior caudal vertebrae are distinguished from the posterior lumbar only by the former having chevron bones on their under surfaces for the attachment of the muscles which move the tail. The chevron bones are united to the posterior part of the under surface of one caudal vertebra and the anterior part of the under surface of the following vertebra, except the first, which is only attached to the first caudal vertebra. In the space between the two halves of each chevron bone is situated the caudal plexus, which, like those in the neck, contains arterial blood. The total number of vertebrae in the *Balenoptera rostrata* is about forty-eight or fifty; of these, seven are cervical, eleven dorsal, twelve lumbar, and eighteen or twenty caudal. The heads of the ribs never reach the bodies of the vertebrae in this or any of the whalebone-whales; they are only connected with the bodies of the vertebrae by fibrous tissue.

The attachment is, therefore, loose, and permits a considerable amount of free movement to take place; as a consequence, the animal has the power of expanding its chest to a great extent. The sternum is always rudimentary or of small size, and of the form of a Latin cross. All the ribs are free or floating, connected together by a band of fibrous tissue, except the first, which articulates directly to the transverse portion of the sternum without the interposition of a sternal rib. The anterior extremity is one of the most curiously modified parts of the body. The animal possesses no power of grasping with it, or of moving it below the shoulder-joint. The whole organ is reduced to the form of a paddle or oar of a boat. The scapula is flat and broad, without a spine; the acromion is a flat process, which rises from the outer surface of the scapula, and projects beyond its anterior border. The coracoid process projects immediately above the glenoid cavity, and is also flattened laterally. The epiphyses forming the posterior border of the scapula unite very late in life, and frequently remains separate altogether. The humerus is very short, and has no bicipital groove; its upper extremity is rounded, while its radial and ulnar surfaces are flat and hollowed out. The elbow-joint is motionless, and has no synovial membrane; frequently, the radius, ulna, and lower end of the humerus, in old animals, are ankylosed. The bones of the forearm are placed side by side; there is no power of pronation and supination. At the distal end of the forearm are two spongy bones, which extend transversely across the wrist, and correspond to the ends of the radius and ulna, but which are never united to those bones except in old animals; in young ones, they exist only as plates of cartilage, with small nodules of bone in their centre. The carpus consists of a plate of cartilage, in which are six bony nodules representing the carpal bones. In the first row there are four bones, and in the second two. It retains an embryonic condition during the whole life of the animal. There is no true synovial joint, nor any motion at the wrist. The digits are composed of alternate rods of bone and cartilage, without any joints between them. There is no trace of a thumb in this or any other *Balenoptera*, though it is present in the *Balena*, and other genera. The number of phalanges is greater in the whale than in any other mammal: in the second finger, there are three phalanges; on the third, seven; on the fourth, six; and on the fifth, three. The muscles of the back of the hand are well marked, and the tendons passing over it from the forearm are comparatively strong, though functionless, to a great extent from there being no motion of the limb below the shoulder-joint.

THE IMMEDIATE SUTURE OF DIVIDED NERVES.

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It has been abundantly proved, both by operations upon man and by experiments on animals, that nerve-trunks unite readily after division. The treatment of neuralgia, for example, by nerve-section has been frustrated in numberless instances by reunion of the nerve and complete restoration of its function. So readily, indeed, do nerves unite, that, to ensure permanent relief from neuralgia, it is requisite to cut out a long portion of the nerve, so as effectually to prevent reunion. "After a long and large experience," writes Weir Mitchell (*Brain*, vol. i, p. 293), "I find that the capacity of nerves to remake their lost parts is almost invincible, and is the true cause of many of our failures to attain permanently the object in view—the relief of pain."

Under other conditions, when a nerve-trunk has been severed in a wound, and has been loosened from neighbouring tissues, so as to admit of wide separation of its ends, it is the exception rather than the rule to meet with reunion. Happy exceptions are the two cases recorded by Paget in his *Surgical Pathology* (p. 211), to show that nerves may "coalesce by immediate union with an exceedingly small amount of new substance formed between them". A boy had his radial and median nerves divided by a circular saw about an inch above the wrist; and, although "no particular pains were taken to hold the ends of the divided median nerve in contact", the arm being merely kept at rest with the wrist bent, returning sensation began to be observed about the tenth day, and in a month the nerve had nearly recovered its conducting power. The second case is that of a lad who had his hand nearly cut off at the wrist-joint by the knife of a chaff-cutting machine; and, although a small portion of integument, the ulnar vessels and nerve, and the flexor carpi ulnaris muscle, were the only structures uninjured, yet the parts were brought into apposition; and, in about ten days to a fortnight after the injury, sensation began

to return; and "finally the sensation of the hand and fingers, and most of their movements, were perfectly restored". It is probable that, in both these cases, the wounds were clean cut, and that there was little or no retraction of the nerves—circumstances conducing in great measure to the correct apposition of the ends, and to their early union. In jagged and lacerated wounds, where the soft parts are separated and torn from one another, it is unlikely that the ends of divided nerves can be brought, without special means, into their relative and accurate positions. And so it is, that the usual history of divided nerves in lacerated wounds has been one which has not told us of repair and of restored function, but rather of abolished function, neuralgia, and the many disturbances of nutrition to which such nerve-lesions give rise. These trophic derangements, which have shed so much light on nervous physiology, have been fully investigated and described by different observers: by Mr. Hutchinson, in the *London Hospital Reports*, vol. iii, 1866; by Dr. Weir Mitchell, in his well-known work on the *Injuries of Nerves*; and by Létievant, in his masterly and exhaustive *Traité des Sections Nerveuses*.

Operations to restore the continuity of divided nerves have from time to time been practised by various surgeons; by some with signal success, as in the more recent cases, to which I shall refer; by others without satisfactory result. Létievant (*op. cit.*, p. 96) records an unsuccessful case of secondary suture of the radial nerve; and Tillaux (*Affections Chirurg. des Nerfs*) records failures by Nélaton and Verneuil. In the twelfth volume of the Clinical Society's *Transactions* (1879), Mr. Hulke relates a successful case of secondary nerve-suture. The ulnar nerve had been divided in a deep ragged cut across the inner side and front of the elbow. The wound suppurated, and closed slowly; and the man was left with anaesthesia in the tract of the nerve, wasting of the forearm and arm, increasing powerlessness, and severe neuralgia at and radiating from the site of the wound. Fifteen weeks after the injury, Mr. Hulke cut down upon the nerve; and, although the ends were widely apart, and it was necessary to make fresh transverse sections of both ends, he was able to bring them together, fastening them with four fine silk stitches passed through the sheath. Sensation began to return about three weeks after the operation; it rapidly improved; and, when heard of five months afterwards, the man had long been working as a smith at a forge. Early in the present year, Mr. Hulke brought another case before the same Society (*Lancet*, vol. i, 1880, p. 288). "A patient, in washing bottles, cut his forearm, severing the median nerve and artery above the wrist. The artery was secured by torsion; and as, on the following day, when Mr. Hulke first saw the case, immediate union appeared to be taking place, he hoped that the divided ends of the nerve would unite. But suppuration followed, and cicatrization was not completed till five weeks after the injury. The anaesthesia of the fingers supplied by the median nerve persisted." The wound was then laid open, and the same procedure carried out as in the other case. About four weeks after the operation, sensibility had returned to nearly all the parts supplied by the nerve, "except the terminal phalanges of the index and middle fingers". Von Langenbeck has had a like result in a case of secondary suture (*Berliner Klinische Wochenschrift*, No. 8, 1880) of the musculospinal nerve eighty-two days after its destruction in the arm by a contused sloughing wound. Contrary to the usual course in such cases, voluntary motion began to be restored before that of sensation; but both appear finally to have been regained.* In recording his first case before the Clinical Society, Mr. Hulke remarked that "the propriety of immediately joining with sutures a severed nerve-trunk exposed in a fresh wound is so obvious, that it has probably been done oftener than is known from published cases"; and Paget (*op. cit.*, p. 213) draws this lesson from the two cases to which reference has been made, that "we may, with good hope of great advantage, always endeavour to bring into contact and immediately unite the ends of divided nerves; and we need not in all such cases anticipate a long-continued suspension of the sensation and other functions of the part the nerves supplied". Medical literature affords but scanty record of cases where immediate suture has been practised; and it is far richer in the history of cases where divided nerves have been left to take their chance, and, with all their evil though interesting consequences, to become involved in the cicatrices of wounds. In his address in Surgery before this Association at Sheffield, Mr. Favell related successful cases of secondary suture of the sciatic and median nerves, and he went on to say (BRITISH MEDICAL JOURNAL, vol. ii, 1876, p. 181): "Two other cases I have records of, in which the divided ends of the nerves were

brought together by suture immediately after the accident. In one case the median nerve, and in the other the ulnar nerve, were entirely divided. Both cases were boys of fourteen years of age. In one month from the occurrence of the accident, both boys were discharged with their wounds healed, and sensation was perfect in each instance". I do not know that these cases have been subsequently published in greater detail; and the record of them is therefore insufficient, in that no mention is made of regained motor power—a matter of no small importance in estimating the restoration of the functions of a nerve. Létievant (*op. cit.*, p. 70) in 1869 performed primary suture of the ulnar nerve, divided in a severe glass-wound just above the wrist, but without success; and he also records a case of suture of the median nerve by Laugier in 1864, within twenty-four hours of the injury. Sensation seems to have returned in this case with astonishing speed, for gross impressions could be felt within a few hours of the operation. Doubt must, however, be thrown upon the accuracy of this observation; for even on the eighth day the perception of finer impressions was uncertain, and there was analgesia in the median tract. Suffice it to say that, in the end, the function of the nerve was restored. To these cases I have now the opportunity of adding two others; one under my own care; and a second and earlier case, for the following notes of which I have to thank my colleague, Mr. Pye.

A lad, aged 14, caught his arm in a printing-machine on August 1st, 1877, and received a lacerated wound behind and on either side of the left elbow-joint, exposing the internal and anterior aspects of the capsule of the joint with the brachial artery, tearing the tendon of the triceps, and chipping off part of the internal condyle of the humerus. The median nerve was torn completely across. The ends of the nerve were brought together, as nearly as possible, by catgut sutures, passed through the substance of the nerve, and through its sheath. The wound was lightly dressed with carbolic acid, and the arm was placed on an angular splint. From August 1st to August 8th, the motor and sensory paralysis appeared complete in the hand and in the muscles of the forearm supplied by the nerve. Then there began some pricking and tingling of the forefinger, soon followed by commencing power of flexion. The return of sensation, once started, returned rapidly, and was nearly complete by the end of the month. The ball of the thumb and the radial side of the middle finger remained insensitive throughout. The return of muscular power was fairly good, but was more difficult to estimate, in consequence of the cicatrization of the wound. It seemed, however, to be slower than that of sensation.

This is my own case: James A., aged 19, was admitted into St. Mary's Hospital on September 8th, 1879, blanched and collapsed from loss of blood caused by a wound of the right arm, received in falling through a skylight. The wound was extensive and lacerated, situated about two inches above the bend of the elbow, and it extended downwards and inwards towards the internal condyle, severing the biceps muscle, the brachial and other smaller arteries, and the median nerve. The vessels having been secured, the ends of the nerve, found separated an inch and a half, were drawn into contact by two catgut sutures passed through the sheath at opposite sides. The wound was dressed by Lister's method, and the arm was placed on an angular splint. It is unnecessary to follow in detail the history of the wound, which healed by first intention, and without more discharge by the drainage-tube from the deeper parts than was to be expected from the extent and severity of the injury to soft tissues. It was manifest, when the man had rallied, that there was complete anaesthesia in the regions of the median distribution, with entire loss of motor power. From day to day, the fingers were carefully tested, both as to sensation of touch and of pain; and, on September 17th, he first spoke of occasional tingling in the index and middle fingers. On September 18th, the tingling continued, and a touch was perceived on the ulnar side of the middle finger, though referred to the radial side of the ring finger. On September 19th, his fingers were sensitive to pinching, which made them feel hot, though not to the finest touch of a pin. On September 22nd, he was just able to localise the touch of a pin on the palmar aspect of the middle finger, and pricking the pulp of it produced a shooting sensation up the arm. Sensation had so far improved on September 24th, that he was able to recognise the touch of a pin, at once, on the thumb, and, after a momentary pause, on the index and middle fingers, though he usually referred a touch on the ulnar side of the index to the radial side of the middle finger. Like errors in localisation continued in these two fingers, although the facility of perceiving tactile impressions gradually improved; and, on September 29th, it is noted that much finer touches were felt with greater readiness. The sensation of the middle finger was, throughout, better than that of the index, and that of the thumb better than either. On October 2nd, he stated that his fingers—that is, the fore and middle—felt sometimes as if he were bending them, though, on testing, he was found to have no

* Successful cases, unknown to me when this paper was read, of secondary nerve-suture have been recorded by Mr. Holden and Mr. Savory in vol. xvi of *St. Bartholomew's Hospital Reports*; and I have recently performed secondary suture, with varying degrees of success, of ulnar nerves, four months and six months after division. These two cases will be published when the histories are complete.

power of flexion. He could not flex the last phalanx of the thumb, nor oppose it to the fingers. By October 9th, tactile impressions were invariably felt, though feebly, and not without errors in localisation. The sense of heat, however, seemed absent, for, too anxious to experiment upon himself, he touched the bar of the fire, and raised a blister on the dorsum of the last phalanx of the index finger. The sore thus caused was nearly a month in healing, but it healed perfectly, and has remained healed up to this time, affording evidence of the absence of trophic disturbance in the part. Early in October, he regained some power of flexing the index and middle fingers, but none over the last phalanx of the thumb. He was discharged on October 14th, with the instruction to begin movements of the arm, hitherto kept almost entirely in the flexed position. On December 22nd, he was examined by Mr. Pepper, who made the following note. "Sensation: Perfect on back of hand and fingers, except on fore and middle fingers beyond the middle joint, when it becomes almost *nil*. On palmar aspect, sensation impaired in whole of middle finger, and in the forefinger up to the distal joint. Over the pulp of the forefinger, there is complete loss of sensation. Sensation over the palmar aspect of the thumb is perfect. Motion: Forearm in position of slight flexion, the cicatrix preventing complete extension. Flexion at elbow good; pronation and supination checked by cicatrix. Flexion of wrist normal; also that of ring and middle fingers. Forefinger flexed only at proximal joint. Thumb cannot be opposed completely to any of the fingers. No power of flexion at distal joint, and partial loss at proximal joint of thumb. Extension of wrist and digits normal. He can lift and carry a pail of water, and use the reins in driving." Still further improvement was noted on July 19th, 1880, when he was last seen. As far as movements were concerned, I failed to detect any but the very slightest difference in the two arms and hands; and his own statement was that, in this respect, the limb was as good as ever. The forefinger alone seemed a little stiff or sluggish in flexion at the distal joint. There was no area of absolute anaesthesia, though, throughout the whole median distribution of the hand (*vide* drawing), on both palmar and dorsal surfaces,

Anæsthesia varying with amount of shading.

sensation to touch was described by the man as less acute than at other parts. Occasional errors in localisation were noted: thus a touch on the back of the second phalanx of the middle finger was referred to the tip, and touches on the sides of the last phalanx of the forefinger were also referred to its extremity, and he was never certain whether this phalanx was being touched on the dorsal or palmar surface. Sensation was certainly most dull over the terminal phalanges of the fore and middle fingers, and, to a lesser degree, over the last phalanx of the thumb. Owing to this reason, he had some difficulty in picking up a pin. He was not quite sure when he had got hold of it, though, when he had, he gripped it firmly between the thumb and forefinger. Sensation of pain, as tested by pin-pricks, seemed to me rather more marked on the injured than on the sound hand, and he said that very hot water pained his forefinger. The fore and middle fingers were decidedly colder than the others. I could find no area of "over-sensitiveness of sub-cuticular tissues, as shown by pain on pinching and pressure"; a phenomenon discovered by Dr. Weir Mitchell in two cases where section of the median had been practised, and which he has described in a paper "On some of the Lessons of Neurotomy" (*Brain*, vol. 1, p. 297, *et seq.*).

It is obvious from this history that, for all practical purposes, the function of the median nerve has been restored, and that the usefulness of the limb has been retained without any of those trophic disturbances which are often so incessant and so distressing. It enforces this lesson: that, in all lacerated wounds in the neighbourhood of important nerves, it

should be the routine practice of the surgeon not only to stay hæmorrhage by securing the ends of divided vessels, but also to search for, and carefully draw together, the ends of divided nerves. It must, however, be admitted, that restoration of the nerve's function has not been entirely perfect—perfect, that is, to an extent wherein sensation might have reached the state in which it presumably was before the injury. An explanation of this deficiency may perhaps be found in the impossibility of bringing the nerve-ends into such precise apposition as shall ensure the contact and union of each individual fibre with the fibre originally belonging to it. As Paget (*op. cit.*, p. 211) writes of his first case: "The imperfection of the recovery is just what one might expect in such a mode of union. One might anticipate that some of the fibres in one of its portions would fail to be united to any in the other portions; and the parts supplied by these filaments would necessarily remain insensible. So again, we might expect that some of the fibres in one portion would unite with some in the other, with which they were not before continuous, and which supplied parts alien from those to which themselves were destined; in all such dislocations of filaments, there would be confused or transferred sensations; but, amongst all the fibres, some would again combine in the same continuity in which they had naturally existed; and in these cases, the function would be at once fully restored." It is difficult to conceive that, by any chance short of miraculous, any nerve-fibre can ever, after division in a nerve-trunk, become once more accurately continuous; but, whatever be the right explanation of the defective restoration of sensibility, it is perhaps a question whether, in any case of suture or natural union of divided nerve, there can be, until after the lapse of a very considerable time, an entirely perfect return of sensation, as revealed by finest tests in the sensory distribution of the nerve. In the case which I have related, improvement has been gradual and slow, and there is reason to believe that the improvement has not yet ceased.*

Nerve-suture has been practised so seldom, and indeed the opportunity for it are comparatively so few, that we cannot speak with certainty as to the best material wherewith to tie the ends together. Silver, silk, and catgut have each been used. Von Langenbeck, in the paper already mentioned, writes strongly in favour of catgut, as less likely to cause irritation, to interfere with early union, or to do harm by being passed through the trunk of the nerve itself. Gluck (Virchow's *Arch.*, Band 72) found catgut to be the best material in making his experiments on the reunion of nerves; and Bakowiecki likewise (*Gazette Médicale de Paris*, vol. vii, p. 532), as the result of experiments on various animals, advocates catgut as not productive of suppuration, and because of its disappearance in the wound. He further advises that the suture should pass only through the neurilemma. It seems clear that such a method must be preferable; and, judging from the ease with which the ends of the nerve were brought together in my own case, it will probably be found unnecessary, I think, to pass the suture through the nerve-trunk, a procedure requisite only in the suture of nerves much smaller than the median; or when the nerve-sheath is too delicate to admit of the traction which, in secondary suture may be needed to draw the separated ends together.

Of infinitely greater importance than the mode of suture is the avoidance of suppuration in the wound. Suppuration "interfered with and terminated the early efforts at repair" in a case of divided median which is recorded by Weir Mitchell (*op. cit.*, p. 85); and the same remark would seem to apply to the cases of Mr. Hulke. The failure in Létiévant's case of primary suture of the ulnar nerve was obviously due to profuse suppuration, and to the disturbance of parts by secondary hæmorrhage. To the absence of suppuration, Von Langenbeck attributes, in great measure, the success which attended his operation, and I have no doubt that the same cause contributed in no small degree to the success of my own. Suppuration, and the method of repair accompanying it, can only tend to disturb the earliest efforts towards union, and ultimately involve the nerve-ends in an irregular and painful cicatrix, with the resulting neuralgia and trophic derangements which together make a useless limb. If the mode of dressing which is known by Mr. Lister's name can with certainty ensure that wounds shall heal without suppuration—and there must be few who doubt it can—then it will play an essential part in the restoration of nerve-continuity, whether suture has been required to bring the separated ends together, or they have lain in contact without extraneous aid.

* In January of the present year, the man came to me, complaining that he had had to give up his work because he had so much pain whenever he placed his hand in cold water. With this exception, the limb, as far as motion and ordinary sensation were concerned, was as useful as ever it was. The exception, however, is important; and it would be interesting to know something more of the after-history of cases in which the restoration of nerve-function and continuity has been described as perfect.