can inspect it thoroughly by itself alone and see how it is situated in the place at which I said that the muscle [*M. thyrohyoideus*] springing from each of the two lower ribs of the hyoid bone connects with and joins the thyroid cartilage of the larynx. If you cut through this muscle, and with the one hand draw upwards the hyoid bone, and with the other hand draw the thyroid cartilage downwards, you find the place [interval] between the two occupied by the structure that is common to those organs which I mentioned. Of that we shall speak later on. But now I assume that the larynx of the animal has been detached and completely removed, and I will begin on the elucidation of the nature of its particular [special] parts, and make them clear. I say that the first, that is the thyroid, cartilage has four borders as I described, which go along it in four lines. Two of these are vertically upright in the direction of length, one on each side, and I will call these two the sides of this, the first cartilage. The two others go transversely, one of them above, where the hyoid bone lies, and the other below, where the end of the cricoid cartilage is. But the second cartilage [*cricoid*] has two sides, which affix themselves to the vertical sides of the first cartilage [*thyroid*], and in fact they are correspondingly vertical, precisely as the two sides of the thyroid cartilage. It [the second cartilage]
100 has a third side, above, extending sideways like the upper border of the first cartilage, and situated as it were correspondingly over against that, and it stands back from that [the first cartilage] at a considerable distance, thus producing the hollow space of the larynx. But at its lower end, the second cartilage has no second line which marks its border and courses along it as is the case in the first [cartilage]. That is because from each of its two lower angles by means of which it is articulated with the first cartilage through an articular ligament, an obliquely directed process juts out, which is twisted and inclined in a direction inwards and forwards. For that reason each of these two processes soon meets its counterpart, and from them is derived a three-sided figure, the base of which is the lower line of the [second] cartilage. The mid-space between the three sides of this triangle is filled up by two muscles [*Mm. cricothyroidei*], whose function is to draw the ends of the two laryngeal cartilages towards one another when they both contract. Try to make yourself adequately acquainted with these two muscles by

cutting first through those of their fascicles which lie superficially and then those which are in the depth. For those muscles comprise two layers, as their fascicles embrace [enclose] the lower border of the thyroid cartilage on both aspects, I mean the outer and the inner. On the further side of the line which passes from below round the thyroid cartilage, their fibres occupy no great space either without or within. On the contrary, they take over only so much [space] as they require for their firm attachment at the union of the two muscles. If you dissect or cut these two muscles [*Mm. cricothyroidei*] clean away, and in addition you cut through the muscle going transversely, of which I said that it binds together the first cartilage with the oesophagus [*M. thyropharyngeus*], then you can clearly see the two muscles which attach themselves behind to the second cartilage [*Mm. cricoarytenoidei postici; cricoid cartilage*]. A sharp median ridge separates the two, and parallel to 101
the sharp ridge there is yet another line by each of the two of them, which goes from above downwards, opposite to the other side of each of them, where you see the first cartilage adjoining the second throughout its length from above downwards. Of the lines which limit these parts one may consequently say that they go straight from below directly upwards, and again that they travel from above downwards. That is because in things outside the body you find that what you mean when you use the notion of a path leading somewhere is a single thing and a single notion, in that you can use the term 'travelling' of those who traverse it both upwards and downwards. The position is the same with the lines which bound the muscles along the length of the neck. For you find that they can be said to go from above downwards, and from below upwards. Whoever thinks of and pictures in his mind their lower endings first, for him they will go from below upwards. And whoever assigns priority to their upper ends, for him they will go from above downwards.

Start

CHAPTER 4. THE RECURRENT LARYNGEAL NERVE (OF GALEN) AND ITS DISTRIBUTION.

Now the nerve, of which I said that it comes from the thorax, proceeding along the neck until it reaches the larynx, is the nerve which the anatomists have neglected to record, and have left without attention

[paid to it], and with which I was obliged to deal in a long exhaustive discussion in the books in which I treated of the Nature of the Voice. It adjoins that part of the larynx, and enters it where the lower border of each of the two muscles that I have mentioned terminates, and at just that spot are also the [R. and L.] joints between the two large laryngeal
102 cartilages. I call these two nerves 'the recurrent nerves' and 'those that come upwards and backwards', on account of a special characteristic of theirs which is not shared by any of the other nerves that descend from the brain. For there is amongst the nerve pairs that spring from the brain one that descends to the thorax, travelling in the neck, and that is the sixth pair [*vagus*]. When the nerves of this pair reach the thorax, from each there arises another pair, and these are two small nerves which mount upwards, travelling in the neck to the side of the trachea, and, at the place described by me, they enter the larynx. Beyond this both nerves pass slightly aslant and come to the inner and upper part of the larynx. And first, there springs off from them a twig which divides itself in the two muscles mentioned [*Mm. cricoarytenoidei postici*]. Then a second twig springs off from them, which divides up in two other muscles which come into position after those, and which take their origin from the upper margins of the second cartilage [*Mm. cricoarytenoidei laterales*]. Afterwards it branches out into two other muscles, of greater dimensions than those mentioned, which take up the principal part of the inner space of the larynx [*Mm. thyroarytenoidei*]. After its ramification in this muscle, it branches out again in those muscles which envelop the base of the third cartilage [*right and left arytenoid cartilages*]; these are very small muscles, and they approach each other so closely that anyone who sees them believes that they are a single muscle [*Mm. interarytenoidei obliqui et transversi*].

Should you wish to examine all this thoroughly, then try to make your dissection by freeing the second cartilage from the first at the two lower joints. It will not prove difficult to recognise these joints and to make their acquaintance, even though they are covered by stout liga-
ments, as soon as you cut through the muscles which I have described
103 to you, which bind together the lower regions of both cartilages, and the muscles behind the cricoid cartilage. You must aim for the place where you see the two first [the first and second] cartilages attached to

one another. At that spot you move the two cartilages about by making them rotate in a circular fashion about their junction, and by drawing each of them up and down and then in two diametrically opposed directions, then once more let them spring back one against another. You must make for the place where you see the part between the two which expands and contracts. There you now draw apart the structures divided by that part, and you cut into the ligament by itself alone, so that you can see the joint between the two cartilages. When you have done that, now begin to go upwards on both sides, along the sides, force the thyroid cartilage away from the cricoid, and set free the one from the other till you can see clearly the muscle springing from the side of the cricoid cartilage [*Mm. cricoarytenoidei laterales R. and L.*]. Then begin to bend back each of the two sides of the thyroid cartilage and press them strongly outwards, first the one side [*ala*], then the other. If you do that, you see there two muscles more massive than the muscle which we mentioned earlier, which arise from the lower region of the thyroid cartilage, and ascend obliquely to the third [*arytenoid*] cartilage [*Mm. thyroarytenoidei*]. Should you wish to see these more clearly, then divide the thyroid cartilage in two halves at its median ridge without cutting out with it any part of the structures lying beneath it, shear away the cartilage and clear all those structures away from it. Then you will have the clearest possible view of the whole of the inner space of the larynx. Otherwise, without bisecting the thyroid cartilage, you can *104* set free the inner lining from it. When you have cut away the cartilage in this manner you can see clearly all the structures found in its interior parts, as well as that which was not previously to be seen. Go to work by starting at the spot of which I said that you see there, entirely by itself alone, the mucous membrane common to the tongue, to the oesophagus and to the larynx, after the muscle has been detached which binds the lower rib [*cornu*] of the hyoid bone to the thyroid cartilage [*M. thyrohyoideus*]. At this spot also you can cut away the whole of the hyoid bone from its contiguous structures and then you can inspect more thoroughly and clearly the mucous covering. As to what concerns the common covering, you see that it connects the epiglottis with the larynx, and binds the two to one another. I have already said that it [*the epiglottis*] is also connected with the hyoid bone to which it is

joined by means of a small muscle [*M. levator epiglottidis*]. In this region there are also fasciae which clothe these structures. As they clothe the epiglottis, the larynx and the hyoid bone, these latter are connected one to the other. Still, these fasciae are very delicate indeed, and the whole strength of the position which these organs occupy is derived from their enclosure by muscles and by that fascial covering which they share. Meanwhile it is really the larynx only with which we are dealing. When you have removed the first [*thyroid*] cartilage from it you then see clearly how it is constructed within. There arise from that common covering certain fasciae in relation with structures of a certain elasticity on the side adjoining the oesophagus and the mouth. The glottis comes
105 from this elastic tissue and from the fasciae. You may call the glottis also a tongue, since it resembles the tongue of a flute in the highest degree, and its position in the larynx is that of the tongue in a flute. But the elastic tissue and the fascial structures of which the glottis is composed, coalesce with the muscle inside the larynx, that of which we said that it arises at the base of the thyroid cartilage [*M. thyroarytenoideus*]. This muscle goes obliquely upwards to the third cartilage [*right and left arytenoids*], and its commencement, its origin and its outgrowth, is underneath at the middle part of the base of the thyroid cartilage, at the spot where the ridge of this cartilage ends. And at this place these muscles meet and connect with one another until, as they slant upwards, they split and part the one from the other, and the one takes the direction of the right joint of the third cartilage and the other that of the left. And now, after each of the two has passed beyond this joint, it joins itself to the arytenoid cartilage. These two muscles [*Mm. thyroarytenoidei*] close the glottis, a task in which they are assisted to some extent by the two-fold muscle of which I said that it, a very small muscle, clothes the base[s] of the third [*arytenoid*] cartilage[s].

This, as I have described it, is the function of the muscles mentioned. But the function of those muscles which lie on each of the two sides of the cricoid cartilage [*Mm. cricoarytenoidei laterales*] is to enlarge the larynx sideways. And when they do that to the larynx, it is to be understood that they do it likewise to the glottis. Similarly, the activity of those muscles which lie behind the second [*cricoid*] cartilage [*Mm. cricoarytenoidei postici*] consists in this, that they draw backwards the parts

of the larynx found in that place, and for that reason they widen it. Thus these four muscles open the larynx and the great muscles which *106* lie within [*Mm. thyroarytenoidei*] and the two small muscles which embrace the base[s] of the arytenoid cartilage[s] close it. You can get a satisfactory view of their working by dissecting away all their parts up to the joints by which they are moved after you have secured their attachments to the third cartilage. Then, when you draw upon the muscle through its origin, towards the head, at the same time you move the whole joint.

In the whole of this musculature, the pair of recurrent nerves distributes itself, and consequently as soon as one cuts these nerves, or bruises them, or compresses them with the fingers or by a ligature, the voice of the animal is damaged, and its resonance lost. As for the other muscles of the larynx, you see that nerve-shoots go to them from the sixth pair itself [*vagus*] during its course along the first [upper] portion of the neck. You see one pair of those twigs reaching as far as the upper laryngeal region, and another [nerve or twig] comes to that muscle of the larynx which goes transversely [*M. thyropharyngeus*] and to the muscle [*M. cricothyroideus*] which fastens the second cartilage to the first and binds the two together. In such a work of dissection as this, you can test the activity of this nerve sometimes by dividing it, or by ligaturing it with a thread, or by compressing it with the fingers. For it is all one which of these you do, nor does it make any difference, except that the nerve which has been cut or contused or crushed does not return or revert to its natural state of activity; but the nerve which has only been compressed by the fingers or by the ligature recovers its activity after a short time if it has not been crushed hard by the fingers or by its ligature, or completely disabled by a slender and strong thread, with which it has been bound tightly. If now you have learned to recognise, in the body of a dead animal, the position of each one of *107* the nerves which are joined and connected to the larynx, then it will not be difficult for you to recognise and find each one of them as they are exposed in the body of a living animal. It is best if you do this on the body of a pig. For in all animals which have a larynx, the activity of the nerves and the muscles is one and the same, but the loathsomeness of the expression in vivisection is not the same for all animals. Because

of that for my own part, as you know already, I illustrate such vivisections on the bodies of swine or of goats, without employing apes. But it is necessary that you should extend your studies and examine the larynx. This is constructed in the same way in the bodies of apes and men, a construction which is shared by the other animals which have a voice. You must, then, dissect a dead man and an ape and other animals furnished with a voice which have, besides the voice, the vocal apparatus, the larynx. For the animals which possess no voice have no larynx either. He who is not versed in anatomy thinks that in regard to the plan of the larynx great contrasts exist among the six Animal Classes, to which this our discussion refers. That is because neither the absolute dimensions nor the shapes of the parts of the larynx are precisely the same amongst all of them, a point which applies also to the number of the muscles which they have here. But as regards the activity of each one of the parts of the larynx, and the service which they perform, these are one and the same in all animals provided with a voice. That is because in the bodies of these animals the intention of the Creator was uniform with regard to the plan of the vocal apparatus, just as his intention was uniform also with regard to the plan of the
108 respiratory organs in those animals provided with respiration. For the contrasts between these organs in the bodies of these animals consists solely in their absolute dimensions and their shapes. Thus it occurred to me during the time when I applied myself to the study of these recurrent nerves, and was seeking out the origin of the voice, that I should investigate the design of this nerve in the bodies of flying animals, especially in such as have long necks, as for example the crane, the white waterfowl with a long neck, and the large bird which all the Greeks normally call by the general name of 'strouthos', that is, the ostrich. And now as I came to the dissection of these animals, and observed the design of these upwardly recurrent nerves, and found that their design was exactly one and the same, I marvelled much at the lack of any trace of slackness or remissness to be found in Creation. Already in the work 'On the Uses of the Parts of the Body', and in the work 'On the Voice', I had established that the nerve which activates the musculature which opens the larynx, and that which closes it, must ascend from the lower region upwards to the larynx, and that this

nerve after it has descended from the brain, must necessarily move in a circle round some organic part which takes for it the place of a trochlea, round which a cord passes in order to turn round it and to return in an upwards direction; and that in the neck no organ of such a description exists. But as I saw the necks of these animals which I mentioned to be very long, I thought that it would not be possible in a slender nerve which has its origin on the brain, that it should first descend as far as the thorax, and that from there a portion of it should return, which would have to traverse the whole length of the neck. But in that point there is in Creation no slackness or remissness, as, in fact, there is none in any other instance. For the sixth pair of the nerves that descend from the brain goes downwards till it reaches the thorax, passing through the lowest part of the neck, through which it passes in *109* the other animals also. Here in this region a nerve branches off from it, which climbs up to the larynx in the bodies of these long-necked animals, just as it branches off and climbs up in the bodies of the other animals.

Now since this is as I have described it, then you can convince yourself as to what damage and destruction affects the voice as soon as this nerve meets with injury, not only in swine, but also, as a whole, in all other animals provided with a voice. However, in order that, when you turn your hand to that in any one of the animal classes, you may be in a position to find quickly and to recognise this nerve, you must examine and dissect the animal [first of all in the defunct state] which you wish to vivisect. The matter is as I have already explained it to you, that is to say there is no need for you to dissect[1] a living animal, whether this be a pig or a goat. Thus you will get what you want. But leave the live apes alone, and turn to these animals. First inform yourself by means of diligent study of the structure of all parts of the larynx in the dead animal. Now I will describe to you the structure of the larynx in the pig, which is as follows.

[1] The text here must be corrupt. The emendation suggested by the apparatus criticus would read: 'there is no need for you to dissect any living animal except pigs or goats. Thus you will....' M.C.L.

When you cut away and extirpate completely the 'transverse' muscles, I mean the muscles which come to the thyroid cartilage [*Mm. thyropharyngei*], now detach the larynx from its connection with the tongue, and you will see that in that condition the animal swallows just as before, and you will see that the larynx displaces itself upwards in precisely the same way as it did before. And I should only like to know whether these facts alone, which emerge visibly in the vivisection, do not invalidate the opinion of those persons who believe that the larynx moves itself together with the muscles of the tongue. One circumstance that ought likewise to invalidate it is something you can see before the vivisection of the live animal. It is the fact in regard to
131 which some [anatomists] go profoundly astray and err most seriously since they do not know that from the two lower cornua of the hyoid bone that muscle [*M. thyrohyoideus*] is attached and implanted upon the larynx which comes from their lower border, and that the muscle which comes from their upper border is connected with the tongue [*M. hyoglossus*]. But they believe that the whole hyoid bone, when it is raised up by the muscle which goes to the tongue, raises the whole larynx with it. And if they say that, it is clear here also that they do not in the least understand the activity of the larynx, that actually it is the organic structure alone which displaces itself upwards and contracts towards its head, that draws up with itself the organic parts to which it extends. However, leave aside this and like matters. For, as I have already told you, I have summarised all that can be said about that in another place. Let us now describe the condition of the nerve of the neck [*N. vagus*], and begin our discussion from another point, as follows.[1]

Start

CHAPTER II. FURTHER EXPERIMENTS ON NERVES IN THE NECK.

I say that to one who through practice has acquired dexterity in exposing the vagus nerve it will become so easy that he will be able to complete the task with a single stroke of the knife. And this is not something which I alone can accomplish, for it is performed by many of my colleagues also. To do the same in his turn is easy indeed for anyone

[1] [Scribal addition:] In this place he speaks of the state of the nerve which one sees in the neck in the living animal.

who is present when one performs it, and who sees it with his own eyes. But to describe it in words is very difficult. However, as I have thought it right in this book to try to serve the advantage of those who have never been present or seen me when I was performing a dissection, I must describe this operation also in the clearest possible way. And so I say that it is best that you extend the animal on its back on a board that is perforated by holes through which run the cords with which its 132
limbs are tethered, so that they [the cords] come through and out on the undersurface of the board, and are so knotted together that they completely prevent the animal from moving about. Previously I have also said that it is best if the animal be a pig. The bristles should be shaved off from those parts which the incision encounters. Now divide them [those parts] with a single incision that runs in a straight line, one on each of the two sides of the trachea throughout the length of the neck. Commence at the trachea, and continue from above downwards for a considerable distance. When you do that, then in this region portions of 'spongy flesh' [*lymph glands*] reveal themselves to you, which you can easily tear out and clear away with the finger-tips without using a knife. Next you can see the artery which is known as 'the artery of stupor' [*A. carotis*], one on each side. With it you can also see the deep jugular vein, and the 'nerve of the sixth pair' [*vagus*], enclosed in a common sheath. Dissect away this sheath from them. Then introduce, between the artery and the nerve, a bluntly pointed hook with an eye, of which the end is moderately sharp, so that it enters easily into the fasciae without any perforation being made in the veins or arteries. And attached to this hook there should be a thread folded into two strands—either a stout thread, such as is suitable for sewing, or a thread such as is used for ligatures. This should run through the eye of the hook in order that when you draw out the nerve with the hook, you can grasp with your fingers one of the two strands of the thread, and withdraw the hook backwards together with the other strand of the thread. If you do that well, then the thread falls beneath the nerve, and when you draw both its ends outwards, the nerve will be drawn up with it, so that it can be ligatured by itself alone, without the artery. And now, when you ligature each one of the two nerves by 133
itself, then you will see what it is that the animal experiences as a result.

What happens is that when the thread has been tightened round one of these two nerves, the animal retains only one-half of its normal voice. And when both of these nerves are tightly constricted with the thread, the result is that the animal remains without any voice whatsoever, except that it then has a kind of respiration which resembles hoarseness of the voice. But should both the [carotid] arteries be ligatured, that does not harm the animal at all.[1]

This is one of the things which can be seen by the naked eye and recognised as a result of this kind of dissection which I have described for you. But here is yet another point that you learn to understand through this, namely the nature of the recurrent nerve [*N. laryngeus recurrens*]. Should you wish to inspect this nerve and investigate it, then draw with a hook upon the two margins of the whole incision. Moreover, on both sides you can extend the incision upwards in the direction of the larynx, incising the skin and reflecting it in its entirety together with the muscle which is called the muscular carpet [*M. platysma myoides*]. When you do that, then, in addition to the recurrent laryngeal nerve (which you see entering into the larynx at its lower border at the spot which you have learned from me to recognise), there also reveal themselves to you all the other nerves which branch off from the sixth pair [*glossopharyngeal*, *vagus* and *accessory*] and the nerve springing from the brain itself. Grasp this nerve also with an eyed hook bluntly pointed. After it there will also appear, as I described to you, the special nerve of the pharynx, that is, the nerve of which the pathway and the course lie deeply embedded and of which the exit from the skull passes between the two foramina of the sixth pair of nerves. But the first of all these in respect of position are the nerves of the seventh pair, which is distributed to the muscles of the
134 tongue. You can very easily constrict this nerve with a ligature, and it will then be shown that the tongue remains flaccid as though paralysed and impotent. By means of the constriction of the nerve of the pharynx with the thread, the hoarse voice, as one hears it in the phase of exhalation, is completely destroyed. Now the nerve of the tongue

[1] The ligature of the carotid arteries seems here to describe an alternative experiment, leaving the vagus nerves untied. The effect of ligature is not noticeable in those species in which the blood-supply to the brain is derived mostly from the external carotid and vertebral arteries.

[*N. hypoglossus*] courses over the osseous portions of the structures which attach the hyoid bone to the skull. And below this nerve there lies in the depth the nerve [*N. glossopharyngeus*] common to the pharynx and the tongue, which is not easy to see and which cannot be secured by hooks unless you first of all displace the artery which goes to the tongue, drawing it outwards by means of a blunt hook. Should you have progressed so far that you have been able to discover this nerve, then draw it upwards far enough to enable you to ligature it, if you want, or to damage it in some other manner. If you do that, you see that the tone of the exhalation of the animal, which still persisted after the damage to the recurrent laryngeal nerve, becomes lost. These are things which you observe and distinguish by means of this procedure which I have mentioned to you. And you observe also that as a result of the damage which has involved the muscles and the remaining nerves of the larynx, only a very slight change comes over the voice in respect of its weakness, power, sharpness and depth. Of that, however, I have already spoken exhaustively in the work 'On the Voice'. Similarly I spoke of the muscles and nerves which lie between the ribs [*Mm. and Nn. intercostales*], from whose slackening or motor paralysis it comes about that the animal is deprived of its voice. Moreover in Book VIII of this [present] work I have described how you should lay hold of these nerves with hooks.

CHAPTER 12. CONCLUSION AND ACCOUNT OF THE LOSS OF SOME OF THE AUTHOR'S EARLIER WRITINGS.

There still remain numerous other features which can be seen in the neighbourhood of the larynx and of the trachea, and which the earlier [anatomists] have not recognised. These are matters that belong appro- 135
priately to the investigation of those concealed movements that have not been recognised. I do not think that I should add them here, because I wish to write a single volume on the concealed unobserved movements, and because in addition to my previous burden another great burden has been laid upon me. For after I had written out the books of the work 'On Anatomical Dissections', as I was very nearly at the end of them, it so happened that there broke out that great fire in which the Temple of Peace was burnt down together with many