people. But we know that these fevers occur irrespective of changes of temperature, though they have much influence in re-exciting it in those who have previously suffered, but not *de novo*. The remedy for all this is better drainage, whilst no more water should be used than is required for the crops.

(To be continued.)

THE GULSTONIAN LECTURES ON PULMONARY CAVITIES: THEIR ORIGIN, GROWTH, AND REPAIR.

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LECTURE I. PART II.—[Concluded.]

I HAVE attempted roughly to describe the leading varieties of disease in which cavities originate. I would invite you now to a review of the situations which they affect. The practical importance of this topographical study is best demonstrated by the advantages which have been gained from a knowledge of the few facts which we already possess relating to the position of cavities. I would specially allude to the clinical results obtained from a recognition of the great preponderance of apex-excision over cavities in other situations. In any case of suspected phthisis, our examination is first directed to the apices, and from a negative result we acquire the certainty that the patient is not the subject of advanced disease. Theoretically, there is a rashness in this conclusion; but in practice, our induction ceases to be rash, in virtue of its scientific basis; for the upper part of the lung has been proved to be almost invariably the seat of the early pulmonary disease. By a due regard to this acquired fact, we are saved much superfluous labour, and not a little unnecessary doubt in forming an opinion.

An inquiry into the causes of this frequency is not foreign to my subject. How great an importance has been attached by former writers to an elucidation of this point, may be perceived from the number and variety of the theories to which it has given rise in the literature of phthisis. The causes which have been suggested may be arranged under two headings: (1) postural; (2) functional.

1. Lebert connects the frequency of apex-cavities with the peculiarities of posture in man; during the day erect, at night generally supine. In what manner the erect posture exerts its influence, he does not proceed to explain; but with the supine position at night, he couples the frequent development of cavity at the posterior aspect of the lung. His arguments in favour of the "postural" theory are supported by observations in comparative pathology. From a careful study of phthisis in monkeys, he concludes that the apex is not specially liable to the disease in these animals. The close analogy of structure between man and ape renders this fact of special value.

The explanation adopted by Rindfleisch, which we will presently discuss, is also based upon the influence of posture. To the same order may be said to belong the suggestion that the apex of the lung is specially exposed to the agency of cold. From clinical observers this view has received no small share of support; we still lack, however, conclusive evidence that the parts of an organ struck by the impression of cold are invariably the seat of the resulting inflammation.

The other causes suggested by authors are mainly functional or anatomical. First among these is the alleged inequality of function at different regions of the lung. From a teleological standpoint, there would be a palpable improbability in the assumption that any part of an organ should remain permanently deprived of function; but it must be admitted that varying degrees of activity may exist not only in different parts of the same organ, but at different times in the same part. The view sometimes put forward, that the air-cells at the apex are larger than those at other parts, requires to be confirmed by practical observation. A demonstration of any such difference in the human subject is surrounded with great difficulties, owing to the possible interference of irregular inflation, of emphysema, and even of *post mortem* distension. Dr. Waters, in his Fothergillian Prize Essay on the Anatomy of the Human Lung, denies the existence of any variation in the size of air-sacs in different parts of the same lung.

Greater probability attaches to the view that peculiarities in the bronchial supply may influence the frequency of the apex-disease. Among the features special to the bronchial distribution at the apex, the relatively larger size of the tubes, and their rigidly patent and circular orifices, deserve to be noticed. But further study is required before any etiological conclusion can be based upon the anatomy of the bronchial system.

The occurrence of pleurisy at the apex has also been advanced as a determining agent. Among other considerations, the frequency with which pain is referred to the clavicular region at an early stage of phthisis, lends colour to the view, although after death the recent pulmonary deposits are often uncomplicated by pleural adhesions.

Before entering further into this etiological discussion, it may be well to sift the evidence as to the exact site of so-called apex-disease. In the later stages of pulmonary consumption, it must be conceded, the vomica commonly extends to the summit of the lung. It is habitual, however, even at this stage, to find the cavity lateral rather than median in its axis; and I may state at once that the extension of a cavity to the periphery is mainly a matter of time. We cannot, therefore, with safety, conclude from the size and position of the late cavity to the size and situation of the earlier disease. Clinical observation supplies us with valuable evidence in our endeavour to settle the question. A careful diagnosis will not fail to convince us that the early consolidations are more commonly seated in the subclavicular region than at the apex. The same fact is often capable of direct demonstration, when at the time of death one of the lungs is as yet but slightly affected. I do not wish to underrate the clinical value of an examination of the supraclavicular space. This is undoubtedly a position in which the signs of the disease are very early perceptible; but I have not encountered breaking-down in this situation with as much frequency as in the inner or in the outer subclavicular region.

With this reservation, I would proceed to discuss the etiology of the apex-lesions. I hesitate to attribute to posture so direct an influence on the localisation of phthisis as is implied by Lebert and by Rindfleisch, and I would look rather for the operation of functional causes. We must assume that all parts of the lung are endowed with breathing capabilities proportionate to their amount of spongy tissue. It would be inconsistent to suppose that any one part of the lung is in this respect at a relative disadvantage. On the other hand, we cannot fail to recognise that the type of breathing normally differs in the various districts. More than any other, the upper region of the chest is the seat of voluntary respiration, as opposed to automatic breathing; and the enlargement of the thorax by drill probably occurs to a greater extent in this than in any other part. In this observation we possess a proof that the breathing powers of the apex are not far behind those of other regions; but also an indirect proof that, under ordinary circumstances, this breathing power remains imperfectly utilised. During the bulk of our existence, respiration at the apex is decidedly sluggish; and, even in the female type of breathing, the pectoral region, rather than the apex proper, is the seat of respiratory activity.

Just as attention and training, combined with exalted vital energies, can effect an improvement of the apex-breathing, impairment of function will follow upon a general loss of tone. Even in conditions of fatigue, depression of apex-breathing is perceptible. In the initial stage of phthisis, the depression to which I have referred is extremely striking. At this stage, an inspiration sufficient to raise the subclavicular region to the normal extent may become a matter of considerable effort; and, whilst the patient breathes quietly, no appreciable forward thrust of the ribs is obtained; yet the lower and more elementary mechanism of respiration, that of the diaphragm, remains in nearly unabated activity.

Viewed in this broad manner, the theory of unequal function as a determining factor in the localisation of early phthisis commands my adhesion. The direct outcome of such a condition of lessened respiration is doubtless lessened aeration of the blood; but local effects yet more important are apt to follow. Greater than the loss of inspiratory vigour is the loss of an efficient expiration. We can scarcely overestimate the value of expiration. It shares with inspiration an influence over the circulation, which may be with accuracy compared to the action of muscular contraction in assisting the passage of blood through the muscles; and it possesses a similar influence over the lymphatic currents in the lung and pleura, as pointed out by Dr. Klein (*The Anatomy of the Lymphatic System*, Part II, The Lung, p. 18). But it is upon the bronchial system that expiration exercises its most beneficial influence. In the absence of good expiratory power, the tubes cease to be cleared of their contents; and, under the influence of the impairment in the general tone of the bronchial membrane, their secretion becomes abnormal in quantity and in kind. These are tangible results, by the side of which we are led to suspect as highly probable

a lessened vitality of the parenchyma and a disturbance of the vaso-motor mechanism.

The stagnation in the tubes of the apex is explained by Rindfleisch in a somewhat different light. Rindfleisch, in his first proposition, states that the secretions of the apex are thicker than those in any other part of the lung. The inspissation would be due to a relative dryness of the apex structures, caused by a subsidence of the blood within the vessels, in accordance with the laws of gravitation; but the mechanical explanation given for the gravitation of blood towards the base is weakened by an omission of the most important among the normal conditions of the vessels. The pulmonary vessels are not only elastic tubes, but tubes embedded in an elastic tissue, which is never quite free from tension. In the variations of the pulmonary tension, and, on the other hand, in the varying contractility of the small vessels, are to be found the real moderators of the circulation. Leaving out of consideration the slight suction which intermittently arises in the large intrathoracic veins, I fail to discover, in the supposed emptiness of the latter, a force capable of materially influencing the contents of the capillary system.

The minor details to which I have alluded in the theory supported by Rindfleisch are, in my estimation, less important than its leading idea. The drift of the theory is to refer apex-disease to local anæmia, as a cause. With such a conclusion, I feel that much of our clinical, and much of our *post mortem* experience, will be hard to reconcile. The derivation of any such view from clinical observation would have appeared to me almost impossible. With better excuse, it might have been urged from a contrast with the immunity from phthisis conferred upon the lung, by the chronic congestion of mitral disease. The rarity of the occurrence of phthisis in those suffering from mitral insufficiency, is generally admitted; but the cause of this peculiarity does not, I would suggest, reside in the large amount of blood contained in the lungs, but rather in the degree of intravenous pressure. It is rational to suppose that the pressure kept up in the vessels by persistent regurgitation may act upon the endothelial membrane to an extent which would discourage the soft cell-growth characteristic of phthisis. Assumption, however, is superfluous in this case. We possess, with regard to the pathology of venous obstruction, a rule which is of universal application. In the liver, in the spleen, in the kidney, interstitial fibrosis is the invariable result of mitral disease. This condition is also induced in the lung from the same cause—thus the antagonism is not between phthisis and congestion, but between fibrosis and phthisis.

For my part, I believe congestion to be never absent from the earliest phases of pulmonary phthisis; but, unlike the mechanical congestion of mitral disease, I hold blood fulness to be here the expression of a local loss of tone. It is comparable to the congestion present in relaxed states of the tonsils and in subacute pharyngitis; and it is similarly coupled with hypersecretion and with cell-overgrowth. This local retardation of blood is directly induced by an impairment of the aerial traffic; for we have seen that regularity and fulness of breathing are essential to the thoroughness of the circulation. Excessive collapse of the alveoli, and their excessive distension, alike constrict the capillaries. Congestion is, on the other hand, most favoured by a state of flaccidity equally removed from either extreme. Of the existence of some degree of congestion as an early condition, we possess clinical evidence, if we are to trust to the usual interpretation of the auscultatory sounds. Anatomical proofs of the same fact are not wanting: lobules are frequently found in a congested state which are unmistakably attacked by an early pneumonic catarrh; and, in other regions, we recognise indelible traces of former congestion in the black pigmentation of the lobule.

To sum up my views as to the etiology of apex-cavities, I look upon the latter as late consequences, in subjects predisposed to phthisis, of alterations at first purely functional, namely, imperfect thoracic movement—imperfect ventilation of the apex, which results in imperfect vascular tone—and, finally, subinflammatory congestion. These conspiring elements are well calculated to awaken in the tissues the dormant predisposition to endothelial proliferation which is at the root of the phthisical habit. With the progress of the cell-growth and of the alveolar distension, a secondary anæmia is induced; but the persistence of the bronchial congestion, and the limitation of the deposits to lobules, clearly show that the disease is determined by the local factor of lobular congestion.

The arguments which I have ventured to put forward in discussing the etiology of cavities at the apex derive welcome support from the rarity of *vomicæ* at the base, where the respiratory conditions are widely different. Primary phthisical excavation at the base is almost unknown in the human subject. The diaphragm is the most automatic of our respiratory muscles, and, as such, unceasingly active. Hence the base, which it can be scarcely doubted is more immediately

under the influence of the contractions of the diaphragm, is also more constantly and more perfectly ventilated. This difference, noticeable in ordinary respiration, is yet more strongly marked in the exaggerated breathing which accompanies cough. It should also be noted that the relatively greater mobility of the inferior wall of the thorax often persists, even in the presence of adhesions; whilst in the upper part of the chest adhesions lead to a more rigid fixation.

Another important factor not to be overlooked, in estimating the comparative respiratory powers at various sections of the lung, is the relative bulk of spongy tissue. The upper part of the lung, which contains the bronchial tree and the large divisions of the blood-vessels, is proportionately poor in alveolar tissue. At the base, where spongy tissue makes up the great mass of the lung, the total strength of the bronchial air-current is likely to be increased, and the respiratory excursions of every constituent part are decidedly amplified.

So rare is the occurrence of primary phthisis at the base, that the evidence pointing to excavation in this situation must be weighed with extreme caution; a searching examination not infrequently proves that cavernous sounds are merely conducted to the base, which at first were deemed strictly basic. When the existence of excavation limited to the base is capable of demonstration, its origin will generally be found to be distinct from phthisis.

Among the causes leading to cavernous sounds in this situation, bronchial dilatation probably holds the first rank; in suspected bronchiectasis, we should never fail to inspect the region immediately below the angle of the scapula, as one specially obnoxious to the disease. Gangrene as a source of excavation is especially common at the base in connection with the relative frequency of basic pneumonia; and empyema leading to pulmonary cavity is equally prone to affect the lower part of the chest.

Syphilis should not be omitted as an occasional cause of basic disease; *vomicæ* due to this affection may be the result of the softening of a gumma or the secondary consequence of ulceration within the bronchi. The relative frequency with which syphilitic lesions are described at the base is doubtless due to the difficulty which commonly attends a distinction between a specific affection at the apex and the ordinary results of phthisis. It is not improbable that *vomicæ* due to syphilis are as often apical as basic. Schnitzler, however, regards the middle and lower lobes as the seat of election for this disease.

Among the many causes which may be classed as accidental, the most important in respect of frequency is the extension of abscesses from neighbouring regions, from the peritoneum, from the liver, from the spleen, or the kidney. Hydatids constitute a separate group of great interest; they may originate within the thorax, or more commonly they make their way upwards from the liver. The impaction of foreign bodies in the lower bronchial divisions occasionally leads to excavation, as in a remarkable case narrated by my friend Dr. Mitchell Bruce in his instructive lectures on Basic Cavities, at present in course of publication in the *Practitioner*. Lastly should be mentioned, although not least important, the softening of the hæmorrhagic nodules, described by Dr. Reginald E. Thompson, which will form the subject of some further description in my next lecture.

With the exception of the last, the diseases which I have enumerated do not strictly fall within the territory of phthisis, although phthisis too often becomes developed in the later stages, and for this reason I reluctantly refrain from any further comments concerning them. This deficiency will be amply supplemented by Dr. Bruce's lectures, which contain a more practical treatment of the whole subject than could have been attempted by me.

Beyond a recognition of the frequency of cavities at the apex and of their rare occurrence at the base, the *topography* of cavities does not appear to have been hitherto specially studied. With a view to supplying some material towards a better knowledge of this subject, I have made careful *post mortem* observations in a series of 152 consecutive cases of phthisis, including five cases of bronchiectasis, and I propose bringing this lecture to a close with a review of the results which I have obtained in connection, first, with the size; and, secondly, with the position of cavities.

(1.) In respect of size the following gradations were noted:—The transformation of a whole lung (with the exception of very small surviving portions) into a single cavity was observed in five cases (three on the right side, two on the left). In addition to these, the left side furnished three other instances of very considerable disease, both lobes being converted into very large cavities which intercommunicated through a perforation in the septum, thus very closely approaching a condition of total excavation.

Excavation of the whole upper lobe occurred in 26 cases. These lobar cavities were situated :

On the right side :
12 times ;

On the left side :
14 times = 26.

Including the 5 cases of total destruction of a whole lung which I have mentioned, the interlobular septum was perforated by ulceration in 23 cases, the lesion occurring :

On the right side :
10 times ;

On the left side :
13 times = 23.

The size of the perforations varied considerably, between the diameter of a goose-quill and that of the lung itself. In all these cases, the excavations were large, and in most the ulceration appeared to have been induced by the downward extension of the cavity from the apex.

For the great bulk of the remaining cases, where excavation did not implicate an entire lobe, standards of comparative measurement were selected in the average-sized Seville orange, in the Tangerine orange, and in the ordinary walnut ; and the cavities were arranged in three corresponding groups.

To the first group, comprising cavities as large as, or larger than, the ordinary orange, belonged 79 of the cases ; the position of the cavities was as follows :

On the right side :
53 times ;

On the left side :
54 times = 107.

Large cavities existed, therefore, simultaneously on both sides in 28 of the cases.

In the second series, numbering 52 cases, the cavities ranged between the size of a Tangerine orange and that of a walnut. They were found respectively :

On the right side :
42 times ;

On the left side :
38 times = 80.

Thus, in 28 cases, both sides were simultaneously excavated (not including several cases in which simple softening existed in the lung least diseased). The usual site of these cavities was the upper lobe ; this, however, was not invariably the case ; for, in 9 instances, the larger cavity was situated in the middle third of the lung.

In a third series of 19 cases, the cavities did not exceed the size of a walnut ; with 4 exceptions, they acquired a larger size at the apex than in the lower lobes. In most of these instances, although the vomicae were comparatively small, the extent of the softening was considerable, and the disease implicated larger portions of the lung than in cases where the cavities attained more important dimensions.

It is unnecessary that I should add any comment to the simple statements which I have enumerated. The figures speak for themselves ; they bring into relief the remarkable evenness with which right and left sides are affected. They also point to a great tendency in the cavities of chronic phthisis towards a progressive enlargement ; and they show plainly that the severity of the disease cannot be estimated by the magnitude of the vomice.

2. If we pass to a consideration of the topography of cavities, we find, in corroboration of the results of other observers, a great predominance of disease in the upper part of the lung. Thus in the whole series, the *apex* presented :

Complete absence of disease.....	in 4 cases.
Pneumonia or blood-deposits (without excavation) ..	3 "
Tubercular masses (without excavation).....	3 "
Tubercle and pneumonic masses (without excavation) ..	1 "

In all the remaining instances, excavations existed at the upper part of the lung. I have abstained from a more elaborate analysis of this region, partly having regard to the uncertainty which exists as to the real limits of what is termed the apex, and partly also from a consideration of the fact that, in chronic cases, the upper part of the lung rarely fails to become finally involved, although not always diseased from the first. It should, however, be stated that the outer region of the apex is found far more frequently than the inner region to be the seat of late excavation.

The *base* afforded a remarkable contrast to this frequency of the apex disease. In the aggregate of 304 lungs, 32 only presented the features of basic excavation ; and at least one-third of these cavities were mere extensions of cavities beginning in other regions, especially in the axilla. Tubercle, both of the sporadic and of the grouped variety, occurred with tolerable frequency. But the deposits more specially characteristic of the base were of non-tubercular nature. They consisted either of hard nodules, such as those described by Dr. Reginald E. Thompson as hæmorrhagic, or of the softer masses which

are so commonly found at the fringe of the lung as one of the latest results of phthisis. It may be incidentally stated that both the hard nodules and the soft masses are liable to break down ; and, if surrounded by the pneumonic oedema which is habitually induced at the base during the last few days of life, they may become the starting-point of extensive disorganisation.

The great frequency with which the sternal region escapes disease will be gathered from an inspection of the following table :

Sternal Region.

	On the Right.	On the Left.	Total.
Absence of lesions ...	71	66	137
Excavation by extension ...	9	16	25
Separate cavities ...	21	15	36
Bronchiectasis ...	6	3	9
Fibrous changes (only) ...	12	16	28
Pneumonia (only) ...	6	7	13
Tubercle (only) ...	6	5	11
Hæmorrhagic nodules (only) ...	4	9	13
Other nodules (only) ...	17	15	32
	152	152	304

The sternal region in its lower portions closely emulates the immunity of the base, but in its upper part it is liable to suffer from the extension of vomicae from the apex and from the mammary region. It further resembles the base in preserving its spongy nature to a late period (thus acting as a reserve of breathing tissue), and in showing a liability to the late nodular deposits which I have mentioned above ; but probably owing to its position in the chest and to its vascular relations it is less subject to the thrombosis and to the pneumonia which so commonly overtake the base.

The *mammary region* forms the subject of the next table to which I would direct your attention.

Mammary Region.

	On the Right.	On the Left.	Total.
Absence of lesions ...	14	20	34
Excavation by extension ...	38	45	83
Separate cavities ...	57	49	106
Fibroid condensation (only) ...	18	18	36
Bronchiectasis (only) ...	3	2	5
Tubercular and nodular deposit in the absence of excavation ...	22	18	40
	152	152	304

The facts expressed by these numbers are, briefly, the following.

The mammary region escapes disease but rarely (in a proportion closely approaching 1 to 9) in cases of advanced phthisis. Excavation, on the other hand, does not occur in more than one-third of the cases. Whether taken separately or in their aggregate, the various figures relating to this region show once more very strikingly the uniformity with which disease affects both sides of the chest. It will be noticed that cavities are more apt to be formed in the left mammary region than in the right, but the latter is more frequently the seat of separate excavation. This difference is partly to be explained by the smaller size of the left lung, and by its anatomical relations, which restrict its expansibility. The greater respiratory surface possessed by the same region in the right lung finds another demonstration in the relative frequency of nodular and tubercular deposits as compared with the left.

A more exact localisation of the vomicae in the mammary region was attempted in fifty-three of the cases only. The central mammary region yielded thirty-one cavities, and the outer nineteen, against three cavities referable to the inner portion of the same district. These numbers are too small to warrant any conclusion beyond the fact that the inner pectoral region is not favourable to excavation.

The *dorsal aspect* of the lung, owing to the space occupied by the vertebral column and mediastinal structures on the one hand, and by the root of the lung on the other, is comparatively of less extent than the anterior surface. The portion corresponding to the vertebral groove is not specially prone to disease ; it is commonly found yet spongy when the mass of the organ is disabled. Excavation in this situation is one of the latest events, and not infrequently it is due to the softening of loose masses of irritative pneumonia, such as I have described at the base. Of the remaining portions of the posterior pulmonary surface, the upper and the lower have been included respectively in the description of the apex and of the base ; and the *mid-dorsal region* I would now propose to consider in conjunction with the *axillary district*, with which it is closely connected in the march of the disease.

In this section of the lung, the following results were obtained from a study of my 152 cases.

Dorso-Axillary Region.

	Right.	Left.	Total.
Absence of lesions	14	15	29
Excavation	111	116	227
Fibroid changes (only)	1	2	3
Compression (only)	—	1	1
Pneumonia or caseation (only)	2	1	3
Edema (only)	1	—	1
Caseating tubercle (only)	—	3	3
Dry tubercle (only)	18	7	25
Nodules (including hæmorrhagic deposits)	5	7	12
	152	152	304

We gather from this table a knowledge of the remarkable proneness to disease peculiar to this region, and of the yet greater proneness to excavation. As in the other parts of the lung, the two sides show but little difference. The excess in the number of cavities in the left axilla, and of tubercle in the right, is probably correlated with the relatively larger extent of breathing-surface at this section of the chest, on the right than on the left side, whereby the secondary excavation is comparatively delayed in the right lung.

In conclusion, I have prepared for your consideration a tabular statement of the frequency of excavation in the various pulmonary regions, derived from the tables given above.

Regional Frequencies of Excavation in 304 Lungs examined.

Excavation at the apices	282
" " dorso-axillary region	227
" " mammary	189
" " sternal	61
" " base	32

The most striking fact revealed by this table is the high proportion which the dorso-axillary excavation bears to the total number of cases of chronic phthisis. I doubt whether clinical observations have hitherto led to so high an estimate of the frequency of the lesion. A knowledge of this pathological fact cannot fail to stimulate a more searching clinical exploration of a region so liable to disease, and to strengthen the conclusions which our diagnosis may derive from physical methods of examination. I will defer until my next lecture a discussion of the pathological meaning, and of the etiology of excavation in this district. My present object was merely to call attention to the existence in the dorso-axillary region of a special tendency to excavation, to point to the clinical value of a due appreciation of this peculiarity, and to submit to you, as an apology for the dry facts with which your patience has been tried, a practical proof of the assistance which anatomical study may render to diagnosis.

ABSTRACT OF LECTURES ON THE MORPHOLOGY OF THE MAMMALIAN SKULL.

Delivered at the Royal College of Surgeons of England.

By W. K. PARKER, F.R.S.,
Hunterian Professor of Anatomy in the College.

LECTURE IV.—THE ENDOCRANIUM PROPER IN ITS GRADATION AND DEVELOPMENT THROUGHOUT THE VERTEBRATE SERIES.

THE notochord is common to both cranial and spinal regions; its proper sheath, as well as the membrana elastica externa and a certain amount of indifferent tissue and embryonic cartilage, also extend into the head. The notochord itself ends in the skull beneath the fold of the mid-brain, the form of which it in some degree takes. The primary condition in which both skull and spine are indistinguishable is very transitory; moreover, the fore part of the skull is deficient as to notochord, and thus, even now, there is this distinguishing character between them. The differentiation between these two regions now goes on rapidly; and one cannot be said to be a modification of the other, for their morphological relations diverge from the first.

Whilst the tissue on either side of the notochord in the spinal region is still quite embryonic, two tracts of cartilage—the trabeculæ—appear

near the cephalic end of the notochord, which they embrace by their hinder attenuated parts. From the apex of the notochord they pass forwards round the base of the fore brain, thus enclosing the pituitary region, in front of which, however, they do not at first unite. This is best seen in the larvæ of the lamprey and axolotl. In these forms, the trabeculæ soon meet in front of the pituitary body, in that which will be the ethmoidal region, and then grow still further forwards, united as a single plate—the internasal plate. This gives off either one broad shield-like plate—as in the lamprey, or two crescentic horns—the cornua trabeculæ—as in the axolotl. In the lamprey, the prochordal trabeculæ are united by a median cartilage—the intertrabecula.

At first, there is no upward growth to form the side walls of this membranous skull. The rest of the basis cranii in the larval lamprey is apparently finished up to the spinal region by a continuous growth backwards of the two bars. In the axolotl, however, there are two new plates of cartilage which finish the basi-occipital region.

Properly speaking, the *prochordal* part of the trabeculæ only receives the name of trabeculæ; the *parachordal* part, whether developed separately or continuously with them, should be spoken of as the investing mass.

The primary skull of the axolotl is more simple than that of the embryo and larva of the lamprey; for the visceral arches in the former are developed independently, whilst, as soon as cartilage can be traced in the larval lamprey, a bar grows out under the emerging fifth nerve, which is the commencement of the great subocular arcade—the counterpart of the suspensorium of the tadpole, of which we shall treat next. In both these cases, the basis cranii in early embryos is very flat, being but little affected by the mesocephalic flexure—a state of things very unlike that which we shall find in the higher types. In the lamprey, after metamorphosis, outgrowths of the basis cranii appear, which are evidently the scarcely differentiated representatives of the mandibular and hyoid arches; there is also a basal bar corresponding in a very generalised form to the basi-hyo-brachials.

In the axolotl, on the contrary, six pairs of visceral arches are developed, besides some small cartilages in the ethmoidal region which become part of the face. As the skull develops, the upper part of the mandibular arch coalesces with the skull-wall close in front of the auditory capsule.

The next important type of primordial skull is found in the Anura. In these, as in the axolotl, two pairs of muscle segments can be seen at the base of the skull; but cartilaginous tissue only appears at first near the end of the notochord, in the postclinoïd region. There, the rounded ends of the trabeculæ abut against the apex of the notochord, and then diverge suddenly outwards, approximating again in the ethmoidal region, and again diverging in the front part of the face as the cornua trabeculæ; still, at this stage, they are quite separate from one another. There is afterwards an intertrabecular tract, both in the ethmoidal and cranial regions. Each trabecula is continuous at its hinder end with a bar of cartilage, which encloses an oval subocular space outside the floor of the fore-brain by growing into the trabecular region where it tends inward in front. This suspensorium, or undifferentiated mandibular pier, ends in front in a short blunt process—the quadrate region—with which is articulated a short mandibular or Meckel's cartilage. Only inferior rudiments, representing the hyoid and branchial arches, are developed at first.

In the case of the sharks and skates, the trabeculæ are half parachordal and half prochordal. They chondrify at first, as in the cases mentioned; but the parachordal tracts chondrify later, and run far into the spine, without any subdivision into cephalic and spinal regions. Afterwards, the two trabeculæ become united together under the fore part of the brain; a styloform intertrabecula appears, and cornua grow forwards on each side. The visceral arches are all developed independently of the basis cranii.

The primordial skull of the sturgeon is very similar to that of a shark or skate; and there is no difference of time as to the chondrification of the prochordal and parachordal tracts: the latter run far into the spine without segmentation, and appear never to acquire an atlanto-occipital articulation. In a bony ganoid, such as *Lepidosteus*, the chondrification of the basicranial tract is continuous from the occipital to the ethmoidal region: thus the parachordals do not extend into the spinal region, and there is no distinction between parachordal and trabecular regions, except that the latter are continued in front of the notochord. A remnant of an archaic condition of the skull, seen also in the early frog or toad, as already mentioned, is that the subocular bar or suspensorium is continuous with the ethmoidal end of the trabeculæ. In the lamprey, it is continuous posteriorly; in later stages of *Anura* in both places; and in the *Urodeles* in neither. The upper part of the hyoid arch is chondrified continuously with the skull.