On the arrangement of the fibres of the heart / by Henry Searle.

ON THE ARRANGEMENT

OF

THE FIBRES OF THE HEART.

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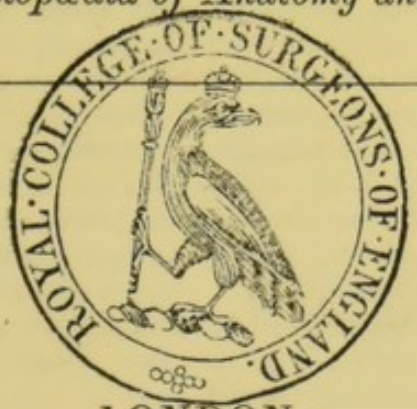
From the Cyclopædia of Anatomy and Physiology.



LONDON:

MARCHANT, PRINTER, INGRAM-COURT.

1838.

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THE FIBRES OF THE HEART.

Preliminary remarks.—In order to unravel the fibres composing the ventricles of the heart, considerable preparation is necessary. The auricles, fat, coronary vessels, and external proper membrane should be cleanly dissected off; the heart should then be boiled thoroughly, but not too much, so as to give its fibres the requisite degree of firmness without rendering them fragile. For example: sheep's hearts should be boiled ten or fifteen minutes; calves' twenty or thirty, and bullocks' forty or fifty minutes; immediately afterwards they should be immersed in cold water; for if they be exposed to the air while hot, their superficial fibres become dark, dry, and brittle. As the process of unravelling occupies many hours, and as the heart requires to be preserved in a good condition, it should be immersed during the intervals in weak spirit and water. The heart of the calf is preferable to that of any other animal, it being on a scale which affords distinct views, while the fibres of young are more easily separated than those of older animals. The conformation is the same in all quadrupeds, and bears a complete resemblance to that of the human heart. When the coronary vessels are dissected off, a depressed line or track is left on the anterior and posterior surfaces of the heart. Since this line corresponds externally to the entire edge of the septum, and to the boundary of the right ventricle, it may be usefully employed in reference to these parts. It is there-

perceptible. At the entire boundary of the right ventricle they decussate, and become greatly intermixed; at the apex and base of the left ventricle they twist sharply round each other, and so become strongly embraced; but in general the interlacement is so slight that they appear to run in parallel lines. Whether a mere fasciculus or a considerable mass of this last description of fibres be split in the direction of the fibres, a number of delicate parallel fibres will present themselves, some being stretched across the bottom of the fissure perfectly clean and free from any connecting medium whatever; and although some must necessarily be broken, yet these are so few that they do not attract attention unless sought for. In this process of separation very little resistance is offered; and none that is appreciable when a single fibril is taken hold of by the forceps, and stripped off, and which could not be done if bound down by cellular membrane.

If a piece of common muscle be afterwards split, it will be found to offer great resistance, and to be attended with so much laceration of the fibres, that instead of a beautiful series of fine muscular threads arranged in parallel lines, a ragged mass of mutilated fibres appears; and during the process of separation, the cellular substance is seen not only to connect the fibres, but to afford the resistance which is experienced.

This comparison obtains in the undressed state of the specimens; but when cooked, other distinctions are met with. For example:

Fig. 1.

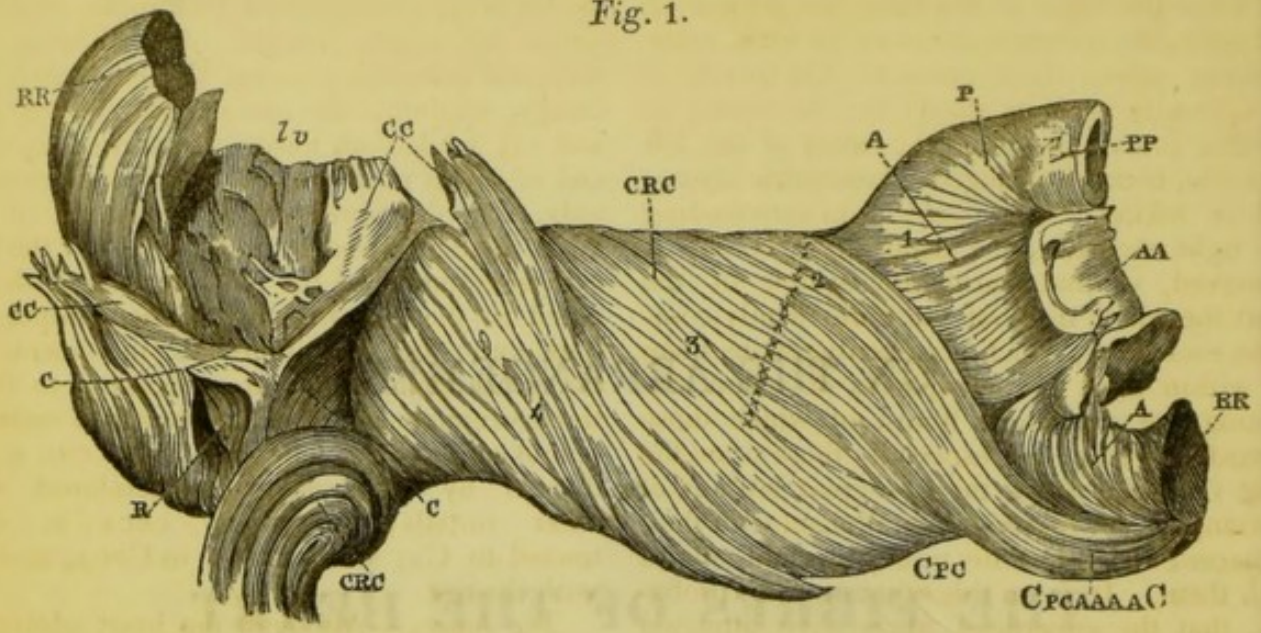


Fig. 2.

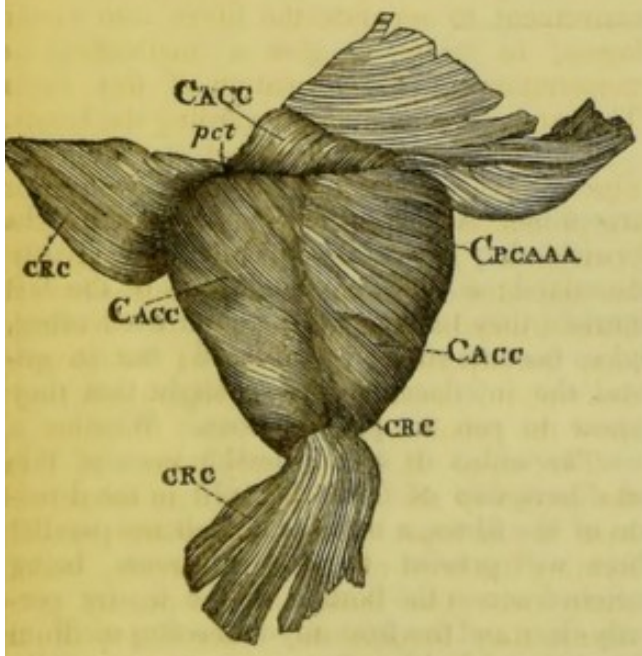


Fig. 3.

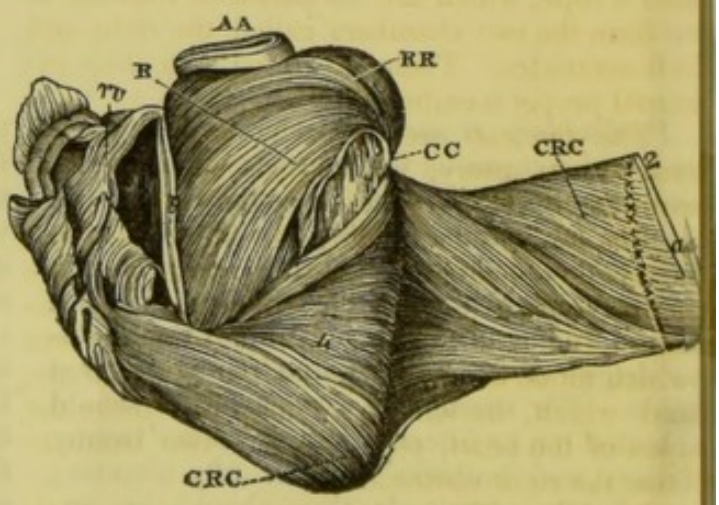


Fig. 4.

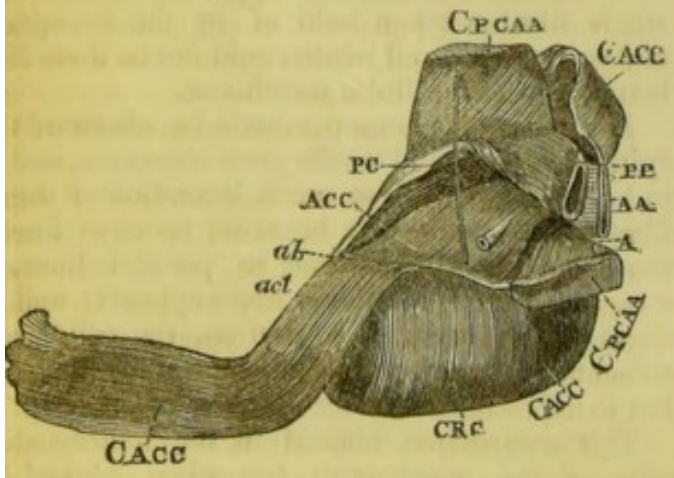
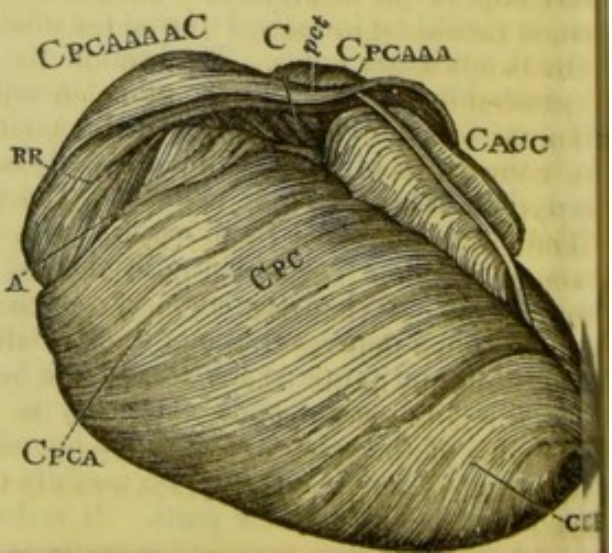


Fig. 5.



them within their proper spheres of action, and since the fibres of the heart are devoid of this agent, the question arises as to what other retaining power these possess. On this head no difficulty presents itself; for the fibres, in winding round and round the cavity of the left ventricle, become arranged in concentric layers; and in taking a larger sweep, in surrounding the right ventricle, the same arrangement is preserved, so that during the systole of the heart the whole mass of the fibres firmly compress each other, which necessarily retains them all within their proper spheres of action, excepting the superficial fibres, of which those towards the base, and especially those upon the right ventricle, where there is great latitude of motion, do not preserve a parallelism with their subjacent fibres, but lie nearly at right angles with them. It is on this account, most probably, that the superficial fibres have attracted notice, and have been viewed as a distinct layer.

The disposition of the fibres varies in different parts of the heart, forming parallel lines, angles, decussations, flat and spiral twists. The fibres are arranged in fasciculi, bands, layers, and a rope, which are so entwined together as to form the two chambers called the right and left ventricles. These are lined with their internal proper membrane.

The fasciculi are connected with the aorta, pulmonary artery, and carneæ columnæ, and contribute to the formation of the bands.

The bands.—By tracing the fibres in bands, we are enabled to develop the formation of the ventricles in a progressive and systematic manner. The bands spring from a mass of fibres which forms the apicial part of the left ventricle, and which, in winding round just above the apex of the heart, separates into two bands to form the right ventricle.

It will render the demonstration more intelligible if a preliminary and cursory view be taken of the general course of these bands (*fig.* 6, *p.* 10,) by referring to the diagram. The bands, as there given, form a mere skeleton of the heart, merely indicating the several courses they take. The average width of the bands is not less than a third of the extent between the apex and base of the left ventricle. In the diagram, CRC indicates the winding of a considerable mass of fibres just above the apex; at the septum, S, it splits into two bands. The shorter, CACC, encircles spirally both ventricles, one half round the right, the other round the left ventricle. The longer band describes two circles: it first passes through the septum, round the left ventricle marked CPCA; it secondly passes round the base, and includes both ventricles in its circuit, marked progressively CPCAA, CPCAAA, CPCAAAAC, and RR.

tions of the fibres and of their respective origins, the latter are characterised by double, and the former by single initials. Accordingly, the aorta, the pulmonary artery, the rope, and the carneæ columnæ are designated AA, PP, RR, and CC, while their fibres are marked A, P, R and C. This plan is modified in one instance only, viz., the fibres of the main bulk of the heart, being derived from the rope and the two carneæ columnæ of the left ventricle, are designated in the first instance by their proper initials CRC; but as numerous increments of fibres are being made, in succession, to these three original sets, it is convenient to make an abbreviation in the lettering; thus, CRC is indicated by C large, when combined with other initials; accordingly, CRCA is contracted to CA, and CRCPCA to CPCA, and so with the rest.

The layers.—Although the heart admits of being split into a number of layers, yet there being no material division formed by fasciæ or condensed cellular membrane, such separations are strictly arbitrary. It is, however, found convenient to separate the fibres into certain layers, in order to give a methodical demonstration of the formation of this organ. The same remarks obtain regarding the bands.

It is generally supposed that the superficial fibres properly constitute a distinct layer, forming a common sac, which encloses the two ventricles. This is not strictly the case, for it has the same origins and terminations as have the fibres immediately subjacent to it. Nevertheless, the superficial fibres are, in the following description, considered as a separate layer, to show the peculiar construction of the apex.

The rope.—It has already been stated that the longer of the two bands terminates at the base in the rope. The fibres of this band, in forming the brim of the left ventricle, make a sharp twist like those of a rope, by which means they become the inner fibres of the chamber, and expand into a layer which enters largely into the formation of the mass which divides into the two bands. So the principal band, although it receives several increments of fibres, has no complete beginning nor ending, a considerable portion of it originating and terminating in itself, which circumstance renders it necessary to fix upon the most convenient part of its course for the commencement of the demonstration.

Although the system here adopted of unravelling the fibres of the heart be strictly arbitrary, as every other must be, yet it will, most probably, be found the only method by which all the various courses, and several connexions made by the fibres in forming the heart, could be displayed.

The demonstration.—It is requisite to pursue two methods of demonstration;—one, describing the *dissection* or unfolding, which

ame time presented. The other, describing he *formation*, or winding up of the fibres, omprehends the retracing of the fibres from he centre to the circumference, showing their espective origins, associations, courses, conexions, and terminations, also the manner in vhich they are wound up to form the two venricles into one compact conical body.

The dissection.—The first stage consists in eparating the superficial fibres from the two entricles, which, perhaps, cannot be accomlished in a more simple manner than by raisng them in the forms of two wings and a tail, s represented in *fig.* 2, which is to be done y commencing at the anterior coronary track, utting through the superficial fibres and deaching them by means of a blunt scalpel in heir natural direction, so far as their insertions t the base; this will be found to divest the ight ventricle, and, from their obliquity, a part f the left. (See the left wing, CACC.) Then ecommencing at the anterior coronary track, ne fibres should be separated in the contrary irection, over the left ventricle towards the pex. These fibres take a very spiral course, nd as they approach the apex converge, but n reaching it they twist sharply round upon hemselves, like the fibres of a thick cord, and ntering at the apex become the internal fibres f this chamber. The remaining part of the uperficial fibres, extending from the apex to ne base, pertains exclusively to the left ventrile; these should be divided an inch or two bove the apex, and the apicial portion detachd, which will complete the tail, &c. Its bres are represented, as they appear after sepaation, untwisted. The basial portion of these bres should now be detached so far as the nnulus arteriosus, and reflected like the right ing, &c. These, as do most other fibres hich approach the base, take a more longitunal course, and in general they become so eparated as they diverge to encompass the asial part of the heart, that they cannot be ised in an entire layer unless some of the bjacent fibres be taken with them.

The second stage of the dissection comprises ne disconnecting the bands which compose the ter or proper wall of the *right ventricle*. he superficial layer of fibres having been reoved, there remain two other layers pertaing to this wall of the ventricle, viz. the middle nd the internal. The *middle* is separable into vo bands, the upper or basial, and the lower apicial. It is better to detach the *apicial* nd first, which makes one spiral circle round e heart. Its outer extremity being attached the root of the aorta at its anterior face, and metimes to the pulmonary artery also, an insion should be made extending from the upr part of the anterior coronary track obliquely wards the annulus arteriosus, which incision

commenced. It here receives on its posterior surface a considerable accession of fibres from the right surface of the septum, by the junction of which this part of the boundary of the ventricle is formed, but the further separation of the band prevented. In *fig.* 4, in the first or basial part of its course it is indistinctly seen, marked CACC. In *fig.* 5 its middle course may be traced, although the half circle of the band which wound round the left ventricle has been cut off. In the preparation exhibited in this figure the separation of this band could not be effected under the posterior coronary track, on account of the separation having been conducted too deeply, where the fibres decussate to form the posterior boundary of the right ventricle. In *fig.* 4, which exhibits a dissection of the right ventricle of a bullock's heart, the whole of the band, CACC, is separated as far as the anterior boundary of this cavity, and lies extended; and the accession of fibres it receives from the right surface of the septum are seen prolonged into it.

The *basial* band crosses the upper half of this ventricle. It cannot be raised from its situation on account of the numerous lateral connexions it forms in its progress with the margins of the orifices of the aorta, pulmonary artery, and annulus venosus. In order to detach it as far as it will admit, an incision about half an inch on the right side of and parallel with the anterior coronary track, should be made, extending from its lower edge to the base, and an eighth of an inch in depth, or as deep as will expose the fibres from the pulmonary artery, which in general pass at an angle with those of the band. Although this band cannot be disconnected from the base, it can in general be detached from the fibres of the subjacent layer, so far as the posterior coronary track; sometimes, however, they are too interwoven to admit of any separation. The first part of this band is represented in *fig.* 4, marked CPCAA; it was divided more than half an inch from the anterior coronary track. Its continuation may be seen in *fig.* 5, lettered CPCAAA, where it is evidently not disconnected from, but merely raised towards the base, and if replaced would overlap the fibres taking the middle course round the heart. The depression at the line of the posterior coronary track, *pct*, is occasioned by the band being bound down at the base and at its under surface also, by which means the upper half of the posterior boundary of this ventricle is formed. As the further pursuit of this band pertains to the third stage, it will be made hereafter.

The *internal* layer. By the separation of the two former bands the internal layer is exposed. It is composed of fibres from the pulmonary artery and from one of the carneæ columnæ. In *fig.* 4 the fibres, PC, are seen

coronary track, joins a band emerging from the septum, and thus forms the apicial half of the posterior boundary of this ventricle. It is raised from its situation, but when replaced its edge, which is everted by the probe, applies itself to the anterior boundary of this cavity. This layer cannot often be so extensively disconnected from its superjacent bands as this figure represents.

The third stage of the dissection.—Having separated the layers composing the right or proper wall of the right ventricle, the next proceeding consists in detaching and unwinding the band and layers composing the left ventricle. First, the detachment of the basial band. As this band has already been detached over the right ventricle in the second stage of the dissection, it is necessary to resume its separation at the posterior coronary track. But as the further separation is somewhat difficult, it will be rendered less so if the remaining portion of this band be first examined in *fig.* 5, wherein it is represented detached. When in its natural situation it forms the uppermost third of this, the left ventricle, and its lower fibres overlap a part of those which occupy the middle third. The fibres which overlap the others in taking an oblique course towards the base reach the brim of the ventricle and pass over it, while the under fibres of this band are appearing in succession, and taking a similar spiral course until the whole bundle of fibres is twisted in the form of a rope. In order, therefore, to trace out and detach this band as it becomes transformed into a rope, it is requisite to commence near the posterior coronary track *(pct)*, in a continuous line with the lower edge of its former portion, introducing the handle of a scalpel obliquely upwards so as to detach the fibres which overlap those of the middle third, and to carry the separation so far up as will reach those marked A, coming obliquely down from the aorta. In conducting this separation from left to right it is soon found that the fibres of this bundle, instead of overlapping others, become themselves by twisting overlapped, rendering it necessary, therefore, to turn gradually the handle of the scalpel obliquely downwards, tracing the rope according to its windings. Two scalpels will be required in conducting the further separation.

The next step should be preceded by viewing the fibres of the rope in *fig.* 3, descending and radiating into a layer which sweeps round the cavity of this ventricle. The heart should now be placed in a small cup or jar of a size that will support it with its base upwards, and then, with the scalpels employed vertically, the separation should be proceeded with, and in passing through the septum a vertical section should be made through the aorta in the line of separation, which should be pursued round and round, and progressively deeper of the heart, and which now pass over the scalpels, should be divided; the incision being made along the side of the posterior edge of the septum. A section should be made through the rope also, which allows the right ventricle to be raised from the left, and the heart to be unwound as far as the separation has been carried. There yet remains a mass of fibres around the cavity of the left ventricle to be detached. This last process of separation should be conducted in a contrary direction to that which has hitherto been adopted, viz. from right to left, until the internal membranous lining is exposed, and which should be torn in order to lay open this chamber.

The heart can now be unwound and extended as in *fig.* 1, placing the left ventricle, *lv*, at one end and the right at the other, removing that section of the aorta, AA, connected to the right ventricle from its counterpart which exclusively pertains to the left, and which is hidden by the rope, RR; removing also the two portions of the bisected rope to the two most distant diagonal points in this view. The niche, CPC, indicates the part occupied by the divided band which passed along the middle third of the heart.

The second method of demonstration.—The formation, or winding up of the fibres of the heart. This description comprehends the retracing of the fibres from the centre to the circumference, showing their respective origins, associations, courses, connexions, and terminations, also the manner in which they are wound up to form the two ventricles into one compact conical body.

The first stage consists in retracing the superficial layer from its origins to its terminations. It is necessary to commence at the very centre of the heart—the interior of the left ventricle, whence spring the fibres composing its main bulk. *Fig.* 4, at its right extremity, exhibits the left ventricle, *lv*, laid open, exposing the two carneæ columnæ, cc and cc, one of which is placed out of its situation, in order to show the interior of the chamber. The fibres of the two carneæ columnæ, cc and cc, expand in a fan-like manner; those of the rope, RR, expand in a similar manner; the radiated fibres of each of these three bodies wind round the axis of this ventricle forming its parietes; and as they wind so as to form an inverted cone, it is clear that the inmost fibres alone can reach the apex. Accordingly, a fasciculus of the inmost fibres from each of these three bodies, marked C, R, and C *respectively*, pass down to the apex associated together, and in their course make a gentle twist from left to right, gradually contracting the cavity to a point and closing it; they then twist sharply round upon each other and complete the apex marked CRC *conjointly*, so that by means of this twisting the internal fibres are rendered

he base, pass more longitudinally. It is evident that these few fibres would be inadequate o form a complete layer, unless in their prolongation they pursued an uniformly spiral course. They are more than enough to cover he apicial part as they twist over each other; ut in consequence of the conical form of the eart they soon become singly arranged, and s they diverge, separate and leave interspaces, ome of which are occupied by fibres which pparently arise abruptly at the surface. The ibres which pass longitudinally to the base of he left ventricle are inserted into the tendinous nargin of the annulus arteriosus, and into the osterior part of the root of the aorta, forming he right wing, CRC. The spiral fibres have een stated to arrive at the anterior coronary rack along its whole length. The majority of hem terminate at the coronary vessels; others re merely intersected by them, while others ass under these vessels and become supericial again: those which maintain their course ver the right ventricle vary in different hearts rom a small to a considerable number. Along he whole length of this track accessory fibres rom the interior of the right ventricle are merging to associate with these in their way ver this ventricle. They take a longitudinal ourse to the base, and therefore start at an ngle with the spiral fibres which are on the eft side of the coronary track. In *fig.* 4 hese accessory fibres from the aorta, AA, and rom two of the carneæ columnæ, are seen assing together obliquely down the right surace of the septum, marked ACC, to enter nto the formation of the extended band. These accessory fibres perforate it along the nterior boundary, *ab*, and become supericial. This layer is, accordingly, in *fig.* 2, narked CACC; its fibres pass at nearly right ngles with the subjacent fibres, and when aised form the left wing; its insertions are he anterior part of the root of the aorta, the endinous margin of the annulus venosus, and gain the right part of the root of the aorta. Sometimes festoons are formed at the base by communications of fibres between the pulmoary artery and the aorta, at its right and posterior aspects.

It occasionally happens that the accessory ibres which arise from the interior of the right entricle are not very numerous; in such cases greater number of fibres arise abruptly from ts surface.

The superficial layer has three sets of origins: one, primitive, from the interior of the eft ventricle; the others, accessory, from the nterior of the right ventricle, and from the uter surface of both. It cannot with propriety be considered as one common investment, since each ventricle for the most part gives birth to its own superficial fibres. It is necessary to raise it as a distinct layer for two the left ventricle, and of forming the apex; and probably no other method than that of the twisting of the fibres could have been so secure, especially as the parietes at the apex of the ventricle do not generally, even in a bullock's heart, exceed a tenth of an inch in thickness.

The second stage.—The external layer having been traced from its origins to its insertions, we may now trace the deep-seated layers; and as these have, for the most part, the same origins, courses, and insertions as the superficial layer, we may commence the description at the same points.

It has been already stated that the fibres of the rope and of the two carneæ columnæ expand in a fan-like manner, that their inmost fibres pass through the apex and become external, but that the chief of them wind round the axis of the left ventricle above the apex, as exemplified in *fig.* 2, CRC. The respective sets of fibres pertaining to these three bodies continue separate during their radiation only, after which they become plaited together by folding one over the others. Their mode of association is shown in the extended portion of the split layer, CRC in *fig.* 3, also in its counterpart, CRC, winding round the apicial part of the ventricle. Again, in *fig.* 1, it may be seen that the fibres at the bases of these columns turn under and pass up in conjunction with those of the rope forming the middle mass, CRC, at the upper of which they fold over making flat twists upon themselves, which have, however, become exaggerated in appearance by the unwinding of the heart, as in rolling it up again some of the angles are converted into spires, preserving a considerable degree of parallelism.

Having shown the origins, and the method adopted in the association, of the fibres forming the middle mass in *fig.* 1, we proceed by tracing the divisions and prolongations of its fibres, and the plan of building up the two chambers of the heart. First, the formation of the *left ventricle*. If the right carneal columna, CC, be replaced in contact with its fellow, and if the rope, RR, be brought round the upper part of this cavity so as to embrace them, and if portion 4 be split from the middle mass, CRC, and be wound, in association with the apicial fibres, CRC, round the lower part of this cavity, that division of the heart, comprising the left ventricle and the middle mass, will bear a near resemblance to that represented in *fig.* 3; in which figure the rope, RR, in embracing the heads of the carneæ columnæ, CC, brings into view its fan-like fibres, R, sweeping round the upper part of the axis of this ventricle; in which the fibres of portion 4, in winding round the lower half of the axis, embrace the bodies of the carneæ columnæ, CC, and associate with the apicial fibres, CRC, and in which the ex-

The third stage. In pursuing the mass of blended fibres, CRC, occupying the middle of *fig.* 1, it is found that, after having formed the left, it splits under the line marked by stars into two bands, which embrace and contribute to form the right ventricle. These separated bands were stated in the preliminary remarks to be of unequal lengths, the longer making two and the shorter making but one spiral circle round the heart. The longer, in the first place, assumes the character of a layer and forms the middle layer of the septum. It requires to be described in three portions. Portion 1, being attached to the valve of the other section of the aorta, was stripped off in unwinding the heart; in the wound-up state it passes over the pulmonary channel of fibres, P, along the part marked 1, in its way to the aorta, AA; its absence, however, opens to view the fibres coming from the base and forming the right layer of the septum. Portion 2 proceeds from the starred line across to enter into the formation of the rope, RR, and will be noticed hereafter. Portion 3 is the longer band; it is not entirely seen, being overlapped by some of the fibres of portion 4; it passes across to the niche, CPC, where it was divided in unwinding the heart, in order to liberate the two ventricles which were encircled together by this band. Previously to pursuing this band further, it is better to trace it as the middle layer of the septum in its natural situation—the wound-up state of the heart. In *fig.* 3 it forms the extended layer, CRC, in association with portion 2, and split from portion 4, which does not belong to the septum; on being replaced, its cut edge, *a*, applies to the cut edge, *b*, in passing as the middle layer between the right and left layers of the septum. The middle layer is seen in *fig.* 5 emerging at the posterior edge of the septum, where portion 2 disconnects itself to join at the under surface the band above, but in this figure is marked C large, indicating that it is derived from this layer, which has hitherto been lettered CRC. This layer, being now deprived of all its other portions, will hereafter be considered as a band, and it has already been explained why it should be denominated the longer band. This band in emerging at the posterior edge of the septum is joined by another band of fibres, which is seen in *fig.* 4, forming part of the internal layer of the proper wall of the right ventricle; its fibres, PC, arise from the pulmonary artery, PP, and from one of the carneæ columnæ not in sight; they cross obliquely over this cavity to the posterior edge of the septum to join the band in question. By the intimate blending of the fibres of these two bands the apicial half of the posterior boundary of this ventricle is constructed. The longer band, now augmented, is lettered accordingly in *fig.* 5

when it arrives at the anterior edge of the septum it becomes the basial band, and having been traced round the left *under* the right ventricle, in making its second circle it passes *over* that cavity. In *fig.* 4 the commencement of its second course is exhibited. It is bisected, one portion, CPCAA, being held up by a probe; the other, at the anterior coronary track *a c t*, receives at its inner surface a fasciculus of fibres, A, from the aorta, AA, and is also lettered CPCAA. This fasciculus and portion of the band form together a groove, by winding over the pulmonary channel when brought down into its place, and which together form the basial part of the anterior boundary of this cavity. This band in its progress round this ventricle constitutes the basial band of the middle layer of its proper wall, and forms so many connexions with the base, that to trace them all would be found a very complicated piece of dissection; it is, therefore, deemed better to give a general description of them. For instance, the aorta presents three different aspects under which this band is connected to it: the first, at the termination of the anterior coronary track; the second, between the pulmonary artery and the annulus venosus; and the third, between the annulus venosus and the annulus arteriosus, or at the extremity of the posterior coronary track. The aorta receives at each of these parts an insertion of fibres from the outer surface of the band; and the band receives on its inner surface a fasciculus from the aorta. These reciprocal communications occasion the band to be very firmly bound down to the base, and to be arranged to a certain extent, into festoons. For each of these accessions from the aorta, an additional A is added to the lettering of the band, which is, accordingly, designated CPCAAAA. As the band passes the annulus venosus, its outer fibres by a gentle obliquity in their course successively arrive at its tendinous margin, into which they become inserted immediately below those of the superficial layer, and some proceeding still more deeply pass under the tendinous margin into the ventricle, and form the musculi pectinati. In order to avoid repetition it may be here remarked, that this part of the description applies to the annulus arteriosus also. The last two accessions of fibres this band receives should be traced, since they assist in the construction of the posterior boundary of the right ventricle. In *fig.* 5 this band is seen in the latter part of its course round the right ventricle, marked CPCAAA; on reaching the posterior coronary track, *pct*, it is joined on its inner surface by two fasciculi which bind it down to the base, but on each side of this track it is separated and raised. One of these fasciculi, the last derived from the aorta, is not seen in this figure; the other appears emer-

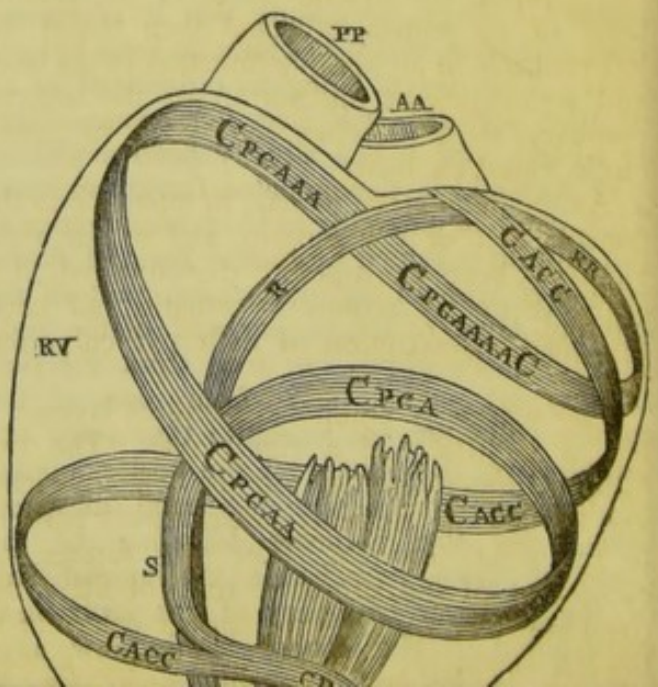
portion 2 is seen crossing over to join the band CPCAAAAC, just before it becomes the rope; the fasciculus of fibres A from the aorta A A is also seen joining this band at its inner surface nearer the base. By the union of these two fasciculi with the band in question, the basial half of the posterior boundary of the right ventricle is formed. By pursuing, in *fig.* 5, this band or combination of fibres, lettered CPCAAAAC, it is seen to form, while it is gradually twisting upon itself, the brim of the left ventricle, and then to make a sharp twist of its fibres into the rope R R, by which means they are rendered the internal fibres of the left ventricle; in *fig.* 3 they may be traced expanding again into a layer, pursuing the same spiral sweep from left to right, but from the base towards the apex, and inwardly instead of outwardly. Thus the demonstration brings us back to our starting-point.

We have yet to trace the shorter of the two bands which originate in the splitting of the middle mass of fibres, CRC, in *fig.* 1, to embrace the right ventricle. This view exhibits only the inner fibres of this mass as they are prolonged into the inner or longer of the two bands; but *fig.* 4 affords an outer view of this mass of fibres as they are prolonged into the outer or shorter band. They are seen winding spirally up from the apex marked CRC, and at the anterior coronary track, *act*, they split, in the form of a band, from the general mass to pass over the lower half of the cavity of the right ventricle. In this figure this band is separated and left extended, in order that the accessions of fibres it receives from the right surface of the septum may be seen, which are the fibres A from the aorta AA, and the fibres C and C form two of the carneæ columnæ (not in view) passing obliquely down from right to left to the anterior edge of the septum, from which they extend into the band which is lettered CACC, and unite intimately with its fibres. When the band is replaced in its course over the ventricle, its accessory fibres are made to reflect at an acute angle upon themselves, and thus form the apicial part of its anterior boundary. This band describes one spiral circle round the heart, arriving again at the anterior coronary track at its basial extremity; it is inserted into the aorta, and if the fibres make a very oblique approach to the base, they will be also inserted into the tendinous margin of the annulus arteriosus. The continuation of this band round the posterior side of the heart can be traced in *fig.* 2. Its width is equal to about a third of the heart's axis; it is seen marked CACC in its spiral ascent from left to right, passing, first, a little below the middle third of the heart; at the posterior coronary track, *pct*, becoming the middle third, and afterwards approaching gradually the base in its way to its points

and concise view by means of a diagram should be afforded of the courses which the fibres take in constructing this organ.

RECAPITULATION. (Vid. the diagram *fig.* 6.) We commence tracing the fibres of the heart from its very centre. The fibres, CC, from the two carneæ columnæ of the left ventricle, LV, are joined by the fibres, R, from the rope RR, after those fibres of the rope have expanded and formed the internal layer of the septum S; in winding round the axis of this cavity they blend together as the initial letters CRC indicate. The inmost of these fibres descend as far as the apex, where they twist sharply round and close the cavity, by which means they construct the apex, and become the superficial fibres of the heart. But the chief bulk of this mass of blended fibres makes a spiral sweep from left to right round the axis above the apex; and when it has described two circles, CRC, it splits at the anterior edge of the septum into two bands, one being considerably longer than the other. The longer first makes one circle round the left ventricle, then another, enclosing both ventricles. In making the first circle it passes through the septum forming its middle layer, and on reaching its posterior edge it receives from the pulmonary artery accessory fibres, which have crossed over the cavity of the right ventricle, forming the inmost layer of its right or proper wall, and fibres from one of the carneæ columnæ of this ventricle, and from the aorta, being marked CPCA. The accessory fibres are not represented, as they would have rendered the diagram complicated and unintelligible; but they are indicated by their initials being added in the lettering of the bands. This band in question may now be traced round the middle third of the left ventricle advancing towards both the base and the outer surface of the heart; on completing its first

Fig. 6.



circle it arrives again at the anterior edge of the septum, receives another fasciculus of fibres from the aorta, and is marked CPCAA. It is then seen to take its course round the base and in front of the right ventricle. As it passes by the right aspect of the aorta, it again receives from it a fasciculus of fibres, and is lettered CPCAAA; on reaching the posterior edge of the septum, it is further augmented by two accessions of fibres, one from the aorta at its posterior aspect, and the other from the middle layer of the septum. This combination of fibres from various sources is indicated by the combination of their initial letters, CPCAAAAC. It should be borne in mind that C large is the synalepha of CRC—the initials of the primitive mass of blended fibres. This band, in passing along the base of the left ventricle, makes at first a gentle twist of its fibres forming the brim of this chamber; it afterwards makes a sharp twist and assumes the form of a rope, by which means its fibres are transferred to the interior of the ventricle. In descending this chamber, they expand again into a layer, and wind spirally round its cavity, first forming the internal layer, R, of the septum, and then associating with the expanded fibres of the two carneæ columnæ, and thus arrive at the points from which we commenced tracing them. We now return to the anterior edge of the septum, S, in order to trace the shorter band. At this part the primitive mass of blended fibres splits into two bands: the longer passes behind the right ventricle through the septum as already described; the shorter passes in front. The shorter first receives a considerable accession of fibres from the right surface of the septum, which pass down from the aorta, and from the two carneæ columnæ springing from this surface: it is lettered CACC; it describes one spiral circle round both ventricles. It first passes over the lower half of the right ventricle, forming the apicial band of the middle layer of its proper wall, and then round the left ventricle in an oblique direction to the base, and terminates at the aorta near the anterior coronary track, having completed its spiral circle round the heart.

As the demonstration has, in reference to the construction of the septum and of the right ventricle, been unavoidably disconnected, it is requisite to give a more systematic and comprehensive description of their particular formation.

The *septum* is composed of three layers: a left, a middle, and a right layer. The two former properly belong to the left ventricle; and the last or right layer exclusively pertains to the right ventricle. The two former are composed of the primitive mass of fibres derived from the rope and the carneæ columnæ of the left ventricle; the left layer being formed CRC; its cut edge *a* applies itself to the cut edge *b*, evidently forming the middle layer of the septum. The last or right layer of the septum has not the same origins as the two former have. Its fibres arise from the root and lower margin of the valve of that section of the aorta which pertains to the right ventricle, from that part of the root of the pulmonary artery contiguous to the aorta, and from the carneæ columnæ of the right surface of the septum. The fibres attached to the aorta and pulmonary artery may be seen in *fig.* 1, lettered A and R respectively, and in *fig.* 4 the fibres from the aorta blended with those of the carneæ columnæ are exhibited marked ACC forming the right layer of the septum.

The right ventricle.—Although the right layer of the septum belongs anatomically to the right ventricle, yet when functionally considered it pertains, as well as the other layers, entirely to the left. For the concavity of this layer is like that of the other layers of the septum, towards the cavity of the left ventricle, and therefore during the systole approaches the axis of this cavity, while it recedes from that of the right ventricle; thereby assisting in the propulsion of the blood from the former, and to a limited extent counteracting the propulsive effort of the latter ventricle.

The right ventricle has, therefore, but one proper wall, which is connected to the left ventricle in a manner to be described hereafter. The right chamber should be divided into three channels: the *auricular*, the *pulmonary or ventricular*, and the *apicial*. The auricular is that which receives the blood directly from the right auricle; the pulmonary is that formed by the fibres which arise from the root of the pulmonary artery at its entire circumference in *fig.* 1, the pulmonary artery, PP, and the fibres, P, are seen turned a little upon their axis, by which means the fibres are rendered oblique, and the channel the more complete; and the apicial channel is that which forms the channel of communication between the other two, and which extends to the apex. The proper wall is considered as having three layers, the superficial, middle, and internal, although they cannot always be detached from each other. The *superficial* is composed of the mere superficial fibres of this wall, having the same origins and terminations as have its subjacent fibres; it forms the left wing CACC of *fig.* 2, and may be seen in *fig.* 4, raised from the right ventricle and reflected over the base marked CACC. The *middle* layer is composed of two bands, the apicial and the basial. The apicial is formed of the first semicircular portion of the shorter band of the heart, and passes over the lower half or apicial channel of this chamber; it lies separated and extended over the apex of *fig.* 4, marked

uricular channels of this ventricle, and is losely connected to the base. The *internal* ayer arises chiefly from the pulmonary artery, P ; it first forms the pulmonary channel, P, nd then expands into a layer which crosses bliquely over the apicial channel, associated vith fibres derived from one of the carneæ olumnæ. The basial portion of this layer vhich crosses over the auricular channel, can- ot often be separated from the fibres of its uperjacent band, the fibres of the musculi ectinati being intricately interwoven with hem. When this layer is replaced, its lower ose edge applies itself to the anterior boun- ary, *a b*, of this cavity, and is lined with its nternal proper membrane. Of the three layers omposing the proper wall of this ventricle, vo, the middle and inner layers, are confined t the edge of the septum, forming thereby the teral boundary of this cavity.

The boundary of the right ventricle.—It is ue that every part of the internal surface of this hamber contributes in forming its boundary. ut, as this cavity is formed chiefly by the litting of the mass of fibres into layers and y their re-union, it is clear that unless the yers so separated were well secured at their oints of junction, their separation would pro- ressively increase, and the cavity enlarge to a tal extent by the repeated dilatations to which is subjected. The mode of union which cures this lateral boundary merits therefore rticular notice. As the lateral boundary rresponds to the edge of the septum, it admits the same division into *anterior* and *posterior*. he *anterior* boundary being formed by the litting of the layers, and the posterior by their -union, their respective modes of construction e not precisely similar. The anterior boun- ary is principally formed by a certain set of res winding and reflecting upon themselves, shewn in *fig.* 4. The basial part of this undary, *a b*, is formed of fibres A, from the rta A A, winding over the pulmonary channel fibres P, in contributing to form the band PCAA. The fibres of this channel also con- ibute to form this part of the boundary, is represented in *fig.* 1. The apicial part this boundary is obviously constructed by e fibres ACC which form the right layer of e septum being prolonged into the extended nd, which on being replaced occasions them be doubled upon themselves in passing over e apicial channel in association with the fibres this band.

The *posterior* boundary is constructed by e re-union of the fibres which pass in front the cavity with others which pass behind it, d by the attachment of some of the fibres at e base to the aorta. The basial half of this undary being formed by the conjunction of e under fibres of the basial band CPCAAA, with a fasciculus of fibres emerging attached to the aorta at its posterior aspect. And the apicial half of the posterior boundary being formed by the conjunction of the prin- cipal part of the internal layers of fibres which cross obliquely the cavity of the right ventricle with the chief part of the fibres of the middle layer of the septum as they emerge at its pos- terior edge, where they freely decussate. In *fig.* 4 the internal layer of fibres, PC, is seen crossing the cavity obliquely towards the apicial part of the posterior boundary, and in *fig.* 5 their conjunction with the fibres which emerge from the septum is seen forming a firm union. But the lateral boundary is rendered doubly secure by the curious circumstance of the coronary vessels, deeply penetrating the sub- stance of the heart along the entire edge of the septum, stitching down, as it were, just on the outside of the boundary, all the fibres which form it.

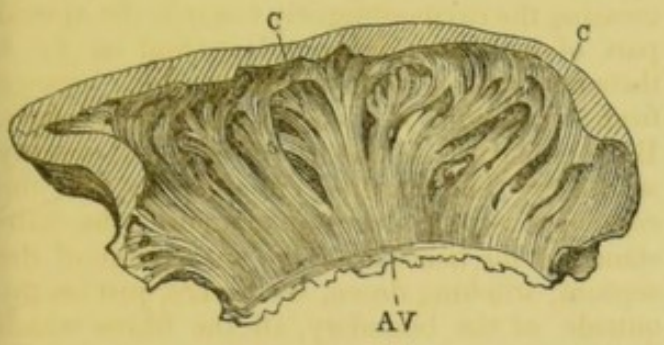
The conical form of the heart.—The only point now remaining for consideration is the conical form of the heart. This form admits of the following explanation. Along the central cavity of the left ventricle are placed the two carneæ columnæ, the length of which is equal to the lower three-fourths of the length of the axis of this cavity. The fibres of these two bodies radiate, as represented in *fig.* 1 ; and the radiated fibres wind round the axis closely upon them, as is seen in *fig.* 3. By this radiation, instead of all the fibres passing longitudinally, which would have preserved these bodies in a state of equal thickness throughout their length, they are progressively parting with their fibres, retaining but a few, which, by their longitudinal course, reach the apex ; consequently these columns gradually diminish, becoming pyramidal, and forming together an inverted cone ; and as the fibres in well-formed hearts wind closely round these columns, the entire ventricle gently assumes the form of a cone. And although the right ventricle is, as it were, appended to the left, yet it is not so connected to it as to destroy the conical form, but, on the contrary, in such a manner as to form a concave parabolic section of a cone which adapts itself to the gentle cone of the left ventricle. The two ventricles thus united assume the form of the more rapid cone of the heart.

Construction of the auricles.—For the pur- pose of ascertaining the mode in which the fibres form the auricles, large hearts, as those of bullocks and horses, should be selected. Not- withstanding the muscularity of the auricles is very much greater in large than in small hearts, yet the plan is the same in both, although less developed in the latter.

The fibres of the auricles arise chiefly from the tendinous margins of the annulus venosus and annulus arteriosus ; they ascend

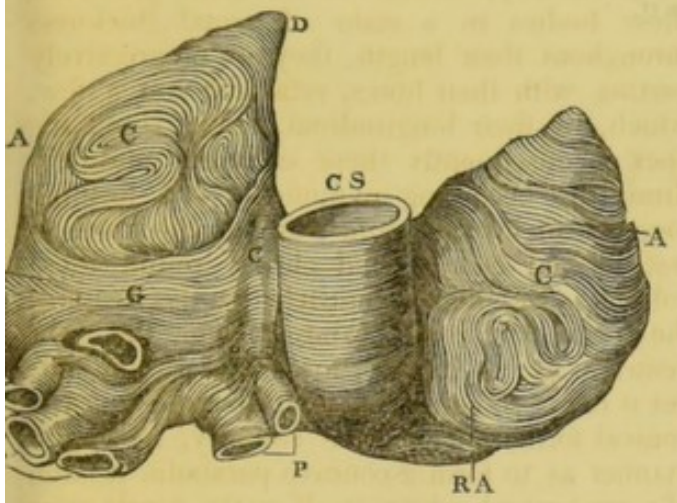
only more slender, but more numerous and interlaced; in these, the interstices in many places are not filled in, the internal and external proper membranes being in contact, and thus completing the wall. *Fig.* 7 affords an interior view of a section of the right auricle, in which,

Fig. 7.



the lining membrane being removed, the fibres are seen arising from the tendinous margin of the annulus venosus AV, forming the internal part of the wall of this auricle, and in their progress up arranged into columns, C, the branches of which are entwined together so as to construct the appendix. These convoluted columns at the posterior aspect of the appendices are flattened, as shown in *fig.* 8, C, where their fibres are associating together, and

Fig. 8.



in passing round the edges to the anterior surface become evenly arranged again, as seen in the appendix A of the right auricle, RA, of *fig.* 9. Thus far the construction of the two auricles

Fig. 9.

agrees, the fibres of each arising from its respective annulus, forming first the inner part of the wall of the auricle, and then being arranged into columns which entwine together, forming the whole of the appendix. The fibres of the right auricle, after having formed the wall of this cavity, are prolonged to form the outer part of the wall of the left auricle. As may be seen in *fig.* 9, the fibres which extend from the convoluted fibres of the posterior surface of the right auricle, RA, wind evenly arranged, some over the apex, and others round the auricle marked C, completing the outer part of the wall of the entire auricle: they then meet at the septum S, across which they pass associated together, marked D, and on reaching the left auricle divide into an upper portion and an anterior and posterior band. The *upper portion* is composed of the continued fibres D, which proceed up the appendix and encircle its apex. The *anterior band* E winds round the left auricle LA, and on reaching the root of the aorta K, its fibres become more or less attached to it in different hearts; in its course upwards, marked F, when it has completed a circle it passes behind the fibres which form the first part of the circle to enter into the formation of the fleshy columns of the appendix. The *posterior band* passes over the left auricle between the appendix A and the vena cava superior CS; and in *fig.* 8 it can be traced coming over, marked G, and passing along the posterior surface of this auricle LA, including in its course the posterior edge of the appendix A; the fibres which pass along the posterior edge of the appendix, on arriving at the anterior edge, separate from the band G to pursue their course round the edge of the appendix,—now along the anterior edge,—and join the fibres D, which cap the apex. This division of the band which encircles the appendix is constant, and evidently affords particular strength to its edge. The band itself G winds down towards the base, expanding and surrounding the orifices of the pulmonary veins P; some of its fibres become lost on the surface of the auricle, and the others may be traced to the root of the aorta.

This band cannot be completely detached in consequence of some of its fibres being interwoven with its subjacent fibres.

The left auricle, without the addition of these bands, would nearly balance in substance and strength the right; their addition gives, therefore, to the left a considerable preponderance in these respects over the right auricle.

The septum S is, in *fig.* 9, shown to be composed, superiorly, of the transverse band of fibres D, which passes from the right to the left auricle; in its middle part, of the ascending fibres H, which arise from the root of the aorta K, and pass up behind the band D, some

nosus to the left auricle, but which cannot be en in this figure.

In concluding these remarks on the construc- on of the auricles, it may be mentioned that in the hearts of large animals a great difference exists in the structure of the two venæ cavæ, the superior being particularly fleshy, and the inferior apparently devoid of muscularity.

THE END.

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