HISTOLOGICAL STUDY OF THE SPECIALISED TISSUE OF THE AVIAN HEART

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ABSTRACT

1. The sinusvenosus being absent in these birds the sinuatrial node has lodged itself in the right atrial wall.
2. Specialised histological structures such as sinuatrial node, atrioventricular node and the atrioventricular bundle are located in the hearts of these birds.
3. The cephalic node e.g., sinuatrial node has the histological features different from atrioventricular node and the atrioventricular bundle. This disparity has been assigned to their location within the atrial tissue in one case and within the ventricular myocardium in another.
4. In the absence of well developed limbs of atrioventricular bundle in these birds a part of cardiac impulse for contraction would pass through the accessory muscle bands of ordinary cardiac fibres present in the right atrioventricular valve and at the junction of the atrial and the ventricular septa.

INTRODUCTION

Purkinje (1845) observed under the serous sheath a network of grey, flat, gelatinous threads in the muscles and around the fibrous bundles of the heart of mammals. On microscopic examination he found these threads to be composed entirely of grains, which, like those of ganglia, were crowded close to each other and appeared polyhedral. Davies (1930) stated that these fibres constitute a special movement apparatus (Bewegungsappart). Kulbs (1913) traced the subendocardial Purkinje fibres in the heart of birds and demonstrated the presence of a tract of tissue resembling the 'Bundle of His' of mammals at the atrioventricular junction. Mangold and Kato (1914) concluded that sinuatrial node is present in the bird's heart near the termination of the right precaval vein and the atrioventricular bundle with two terminal branches in the ventricular septum. The sinuatrial node was described by Keith and Flack (1907) as a mass of peculiar fibres having a few nerve cells and nerve fibres embedded in densely packed epicardial connective tissue. Keith and Mackenzie (1910) regarded this tissue to be intermediate between nerve and muscle fibres and therefore gave it a non-committal name of nodal tissue. Drenann (1927) by the naked eye dissection of the ostrich heart demonstrated that the atrioventricular bundle passes from the dorsal part of the base of atrial septum into the depth of the ventricular septum. Ohmori (1928) observed the atrioventricular connections between the atrioventricular node and the atrioventricular bundle in the heart of birds. Davies (1930) studied the anatomy and the conducting system of the heart of black swans and pigeons. Adams (1937) studied in detail the conducting system of the heart in kiwi and penguin. Inspite of observation on the avian and mammalian heart the specialised tissue has so far not been well illustrated and there is scope for critical study.

Materials and Method

Specimens of *Passer domesticus* and *Pycnonotus cafer* were locally procured and kept alive for a short period in cages. The birds were chloroformed and dissected to remove the hearts. The hearts were fixed in Bouin's picroformol. Both sagittal and frontal sections were cut off paraffin embedded blocks and stained in Van Gieson's picrofuchsin. The localised area in the sections were photographed directly.

Observations

Sinuatrial node

The cardiac muscle fibres in these two small birds are arranged very compactly and are so fine that even in well differentiated stained sections the nuclei were hardly discernible under high power. The structure of sinuatrial node was therefore studied under phase contrast arrangement. In *Pycnonotus cafer* the sinuatrial node is a well defined structure lying on the antero-dorsal surface of the right atrial wall in a U-shaped cavity present between the opening of the left precaval vein and the septum atriorum. The node is lodged within the thin right atrial wall (Fig. 3). The sinuatrial node is not exactly a horseshoe shaped structure, its lower end touches the base of the 'inter-septo-valvular space' and at this end its fibres emerge out to become continuous with the cardiac fibres of the atrial wall. The node is separated from the left venous valve by 4 mm. and from the septum atriorum by 27 mm. The component fibres of the node are not Purkinje fibres although they are thinner than other cardiac fibres. The nodal fibres are arranged compactly within a fibrous membrane.

Atrioventricular node

In *Pycnonotus cafer* and *Passer domesticus* the atrioventricular node is present on the cephalic surface of the septum ventriculorum and the lower wall of the left atrium, posterior to the interatrial septum at the level of the aortic arches (Figs. 2,3). The atrioventricular node is enclosed in a mass of loosely connected fibres. The atrioventricular node is not a well defined structure in *Pycnonotus* but in *Passer* it is a well defined oval mass of Purkinje fibres.

Atrioventricular Bundle (Bundle of His)

The atrioventricular bundle in *Pycnonotus* and *Passer* lies ventral to the atrioventricular node. The atrioventricular node and the atrioventricular bundle in both these birds are connected through Purkinje fibres which are thinner than the component fibres of the node and the bundle. On examination of the serial sections the heart shows that the atrioventricular node is continuous with the atrioventricular bundle at its lower end. The atrioventricular bundle in *Passer* and *Pycnonotus* is composed of fine dense fibres not crossing each other with numerous prominent deeply stained nuclei (Fig. 5). The bundle covers the broad cephalic surface of the ventricular septum and gives tubular extentions on either side.

Accessory atrioventricular muscle bands (Bundle of Kent)

The atria and ventricle in the vertebrate heart are separated by the intervening fibrous tissue which in sections looks like transparent film taking deep red stain. In the serial longitudinal sections of the heart of *Pycnonotus* it has been observed that at the left side of the right atrioventricular opening a prominent band of atrial fibres runs vertically downward and merges with the fibres of the ventricular septum

(Fig. 6). In addition to this, as already indicated, the atrial fibres are closely applied to ventricular fibres in the case of the right atrioventricular valve which is muscular (Fig. 1).

Purkinje fibres

Purkinje fibres are poorly distributed in the atria of both the birds. Besides Purkinje fibres the author observed a distinct band of fibres unlike ordinary cardiac muscle fibres, which took deeper strin. Such a band of specialised fibres was located exactly at a place where the atrioventricular bundle was described by Davies (1930) in the heart of birds, and by His (1893) in the heart of mammals. Serial sections have revealed concentrations of Purkinje fibres on the wall of the aortic arch (Fig. 7).

Discussion

Keith and Mackenzie (1910) and Mackenzie and Robertson (1910) stated that the atrioventricular bundle, the atrioventricular node and the sinuatrial node are absent in birds. Kulbs (1913) was also not definite about the presence of the atrioventricular bundle in birds though he observed a tract of the tissue resembling the 'Bundle of His' of the mammals at the atrioventricular junction of the heart of birds. In the heart of *Pycnonotus* and *Passer* histologically specialised structures in the form of sinuatrial node, atrioventricular node and atrioventricular bundle are present.

The component fibres of the sinuatrial node and the atrioventricular node reported here are identical. Their structural differences with the atrioventricular bundle can be assigned to their atrial and ventricular origins. In the case of the two birds studied the atrial muscle is altogether different from ventricular muscle. The atrial muscle fibres are finer and thinner and thus the cephalic node (sinuatrial) is in less compromise to the septal nodes and bundles.

The atrioventricular node has been described in many avian and mammalian hearts by Tawara (1906). In avian heart it was described by Mackenzie and Robertson (1910) and Davies (1930). Ohmori (1928) described atrioventricular node in the heart of birds at the caudal end of interatrial septum. Adams (1937) described the atrioventricular node in heart of kiwi and penguin between the lowest part of the septal wall of the right atrium and the left ventricle, and embedded in the dense fibrous tissue of the 'trigonum fibrosum'. In *Passer* and *Pycnonotus* the atrioventricular node lies in the cephalic portion of septum ventriculorum and below the wall of atrium sinistrum. At this point the left atrium and septum ventriculorum are separated by a transparent tissue of loosely connected fibres, which is not a dense fibrous tissue like the trigonum fibrosum. Davies (1930) recognised an upper and lower pole in the atrioventricular node in black swans and pigeons, while Adams (1937) observed no distinction of this type in kiwi and penguins. In *Passer* the atrioventricular node is a compact, well defined structure but does not show an upper and a lower pole.

Davies (1930) observed that the atrioventricular bundle in the avian heart runs into the depth of the septum ventriculorum lying between its right and left surfaces, and divides into a right and left limb. In *Passer* and *Pycnonotus* the atrioventricular bundle gives short tubular extentions on either side, which run parallel to the surface of the ventricular septum.

Kent (1913) while making a detailed study of the heart of various mammals reported that the mammalian heart does not show a break in the muscular continuity between the atria and the ventricles and observed numerous atrioventricular muscular connections between the atria and the ventricles. He also pointed out that the idea of a single atrioventricular connection was erroneous. Since then much controversy has raged over the presence and disposition of accessory

Fig. 1.

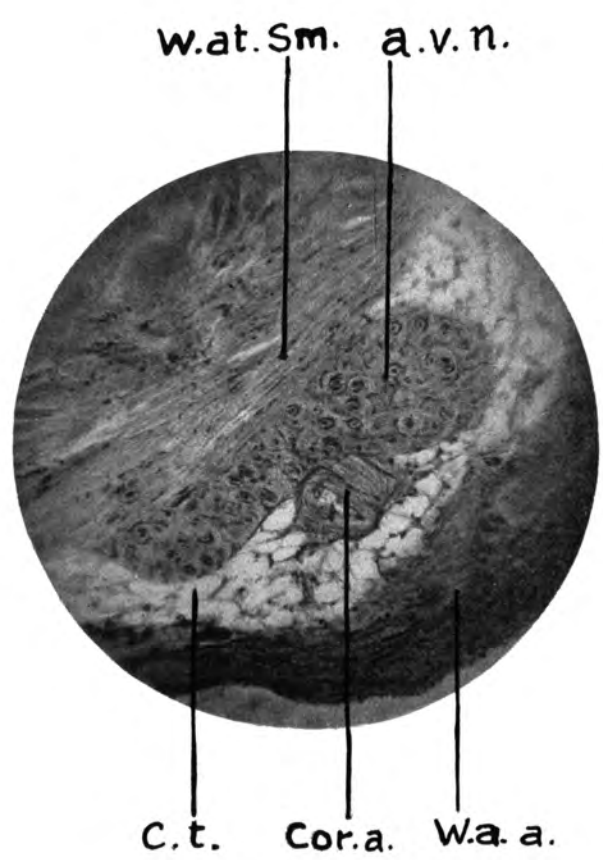

Fig. 2.

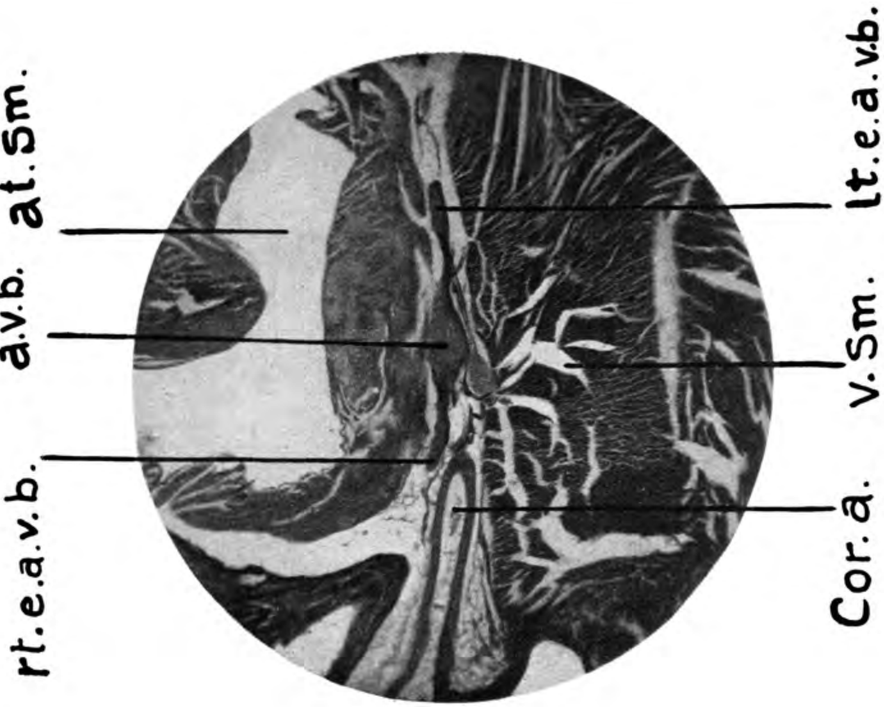

FIG. 4.

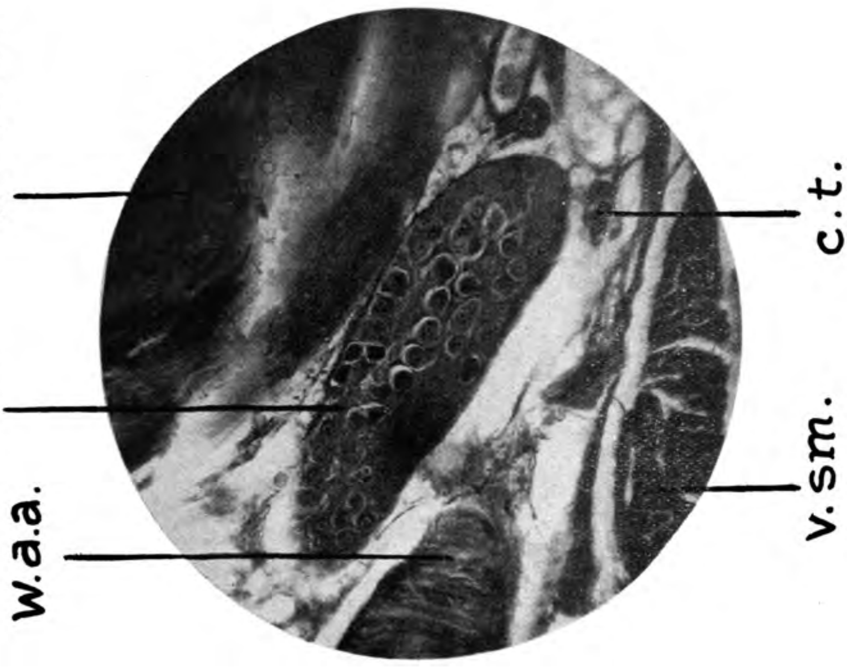

FIG. 3.

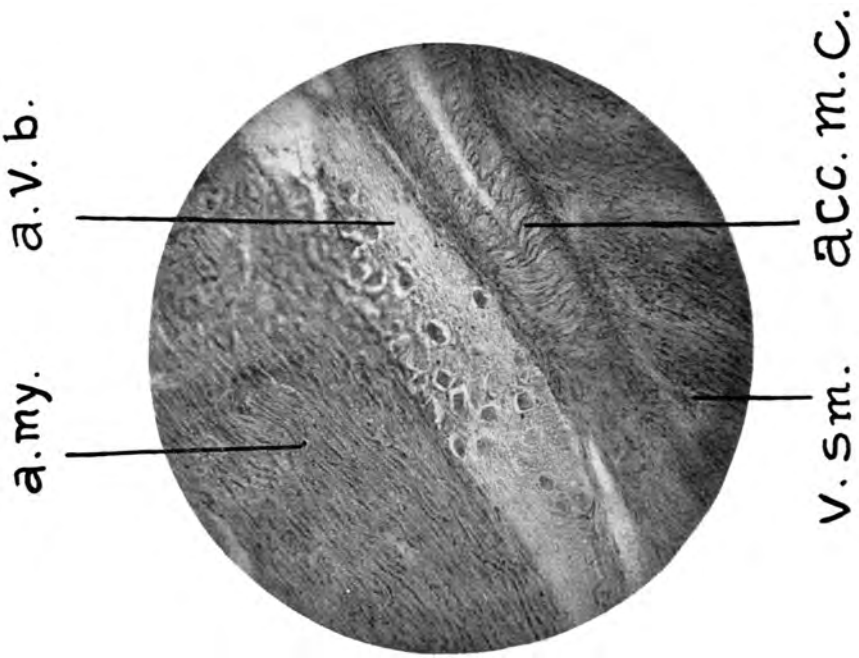

FIG. 6.

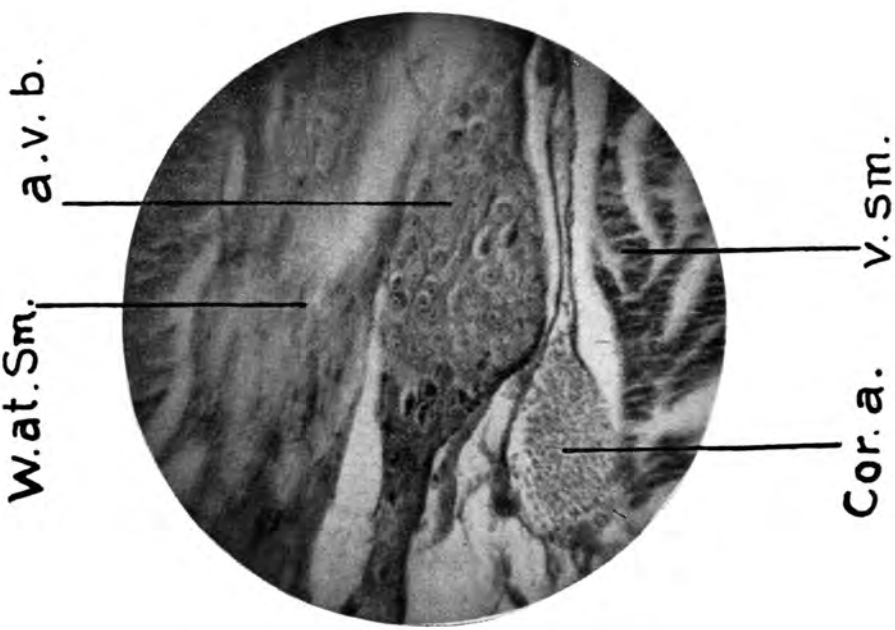

FIG. 5.

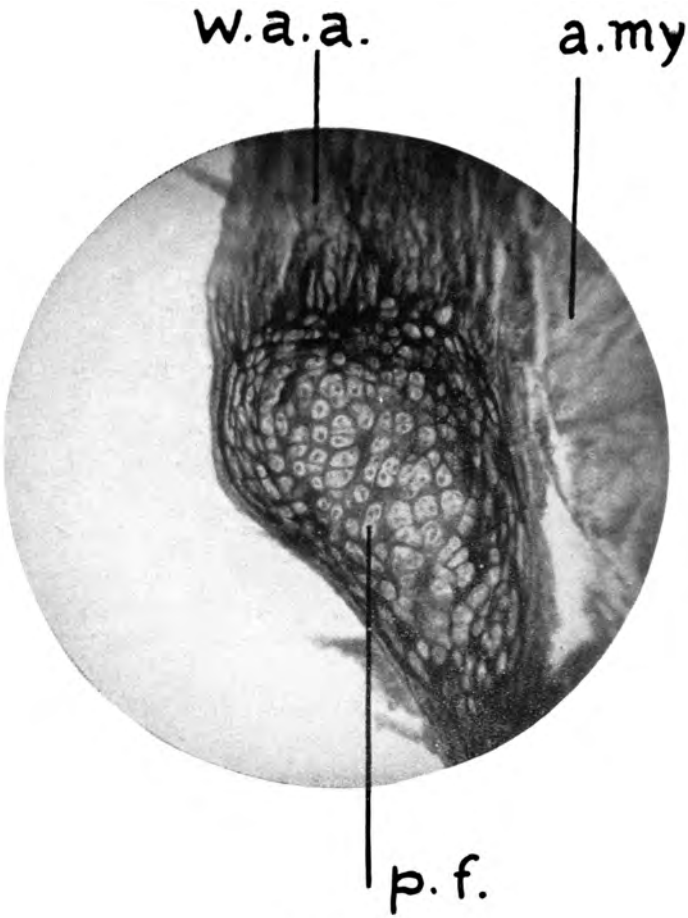

FIG. 7.

atrioventricular muscular connections. The birds lead a very active life and it has a bearing on their rapid rate of heart beat. To maintain rapid conduction of cardiac impulse the presence of well developed conducting system which provides close continuity between atria and ventricles is necessary. The histologically specialised structure e.g., sinuatrial node, atrioventricular node and the atrioventricular bundle in the case of these two birds studied are well defined. The probable path which the cardiac stimulus of contraction may take for being conducted from the sinuatrial node to the ventricle has yet to be traced.

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Explanation of Plates IX, X, XI, XII

(The figures are photomicrographs of localised area)

Fig. 1. Longitudinal section through the heart of *Passer* showing right atrioventricular Valve '× 130'.
Fig. 2. Longitudinal section through the heart of *Pycnonotus* showing atrioventricular node '× 495'.
Fig. 3. Longitudinal section through the heart of *Passer* showing atrioventricular node '× 440'.
Fig. 4. Longitudinal section through the heart of *Passer* showing atrioventricular bundle '× 100'.
Fig. 5. Atrioventricular bundle under high power '× 462'.
Fig. 6. Longitudinal section through the heart of *Pycnonotus* showing atrioventricular bundle and accessory atrioventricular muscular connection '× 490'.
Fig. 7. Longitudinal section through the heart of *Passer* showing rings of Purkinje fibres in the wall of aortic arch '× 150'.

Abbreviations

a.a.	Aortic arch.
a.my.	Atrial Myocardium.
a.v.b.	atrio-ventricular bundle.
a.v.n.	atrioventricular node.
at.dm.	atrium dextrum.
at.sm.	atrium sinistrum.
acc.m.c.	accessory muscular connections.
cor.a.	coronary artery.
c.t.	cardiac tissue.
Lt.e.a.v.b.	Left extension of atrioventricular bundle.
P.f.	Purkinje fibres.
rt.e.a.v.b.	Right extension of atrioventricular bundle.
rt.v.c.	right ventricular cavity.
rt.a.v.v.	right atrioventricular valve.
v.sm.	septum ventriculorum.
v.my.	ventricular myocardium.
w.at.sm.	wall of atrium sinistrum.
w.at.dm.	wall of atrium dextrum.
w.a.a.	wall of aortic arch.