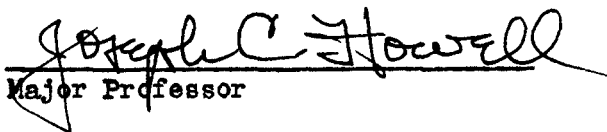


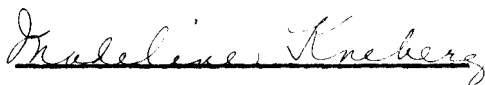
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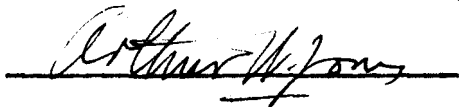
To the Committee on Graduate Study:

I am submitting to you a thesis written by Leslie Wingate Wilson entitled "Variations in the Gross Anatomy of the Heart of Rana pipiens." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Zoology.

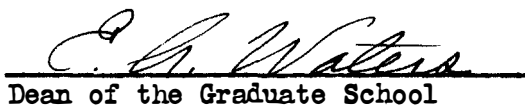

Major Professor

We have read this thesis
and recommend its acceptance:





Accepted for the Committee


Dean of the Graduate School

VARIATIONS IN THE GROSS ANATOMY OF THE HEART OF RANA PIPIENS

A THESIS

Submitted to

The Committee on Graduate Study
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by

Leslie Wingate Wilson

December 1948

ACKNOWLEDGMENT

The writer wishes to express his sincere gratitude to Dr. J. C. Howell for his guidance and cooperation during the course of this study.

The writer also wishes to thank the other members of the Department of Zoology for their encouragement and assistance.

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TABLE OF CONTENTS

CHAPTER	PAGE
I. THE PROBLEM	1
II. THE MATERIAL AND PROCEDURE	2
III. THE NORMAL ANATOMY OF THE HEART.	5
IV. THE VARIATIONS FOUND	15
V. DISCUSSION OF THE VARIATIONS FOUND	25

LIST OF FIGURES

FIGURE		PAGE
1.	Ventral View of the Frog Heart.	6
2.	Dorsal View of the Frog Heart	7
3.	View of the Right Side of the Frog Heart.	8
4.	Dorsal View of the Frog Heart with Part of the Wall of the Sinus Venosus Removed.	10
5.	View of the Ventral Half of the Frog Heart.	11
6.	View of the Dorsal Half of the Frog Heart	12
7.	Anterior View of the Frog Heart with Part of the Auricles Cut Away.	13
8.	Anterior View of the Frog Heart with the Auricles Completely Removed.	14
9.	Ventral View of the Frog Heart Showing a more Ventral Origin of the Conus Arteriosus than is Normal	16
10.	Anterior View of a Frog Heart with the Auricles Completely Removed. Shows a more Ventral Origin of the Conus Arteriosus than is normal.	17
11.	Dorsal View of a Frog Heart Showing Lack of Conus Arteriosus on the Dorsal Surface when its Origin is in a Ventral Position.	18
12.	Dorsal View of a Frog Heart with Part of the Wall of the Sinus Venosus Removed. Shows the Abnormal Position to the Right of the Sinus Venosus and Sinu-auricular Aperture.	19
13.	View of the Dorsal Half of a Frog Heart. Shows the Interauricular Septum in a Position more to the Left	

FIGURE

PAGE

13. (Continued)

than is Normal. 20

14. Anterior View of a Frog Heart with part of the Auricles

Cut Away. Shows the Interauricular Septum in a

Position more to the Left than is Normal. 21

15. Anterior View of a Frog Heart with part of the Auricles

Cut Away. Shows two Auriculo-ventricular Apertures 22

16. Ventral View of a Frog Heart Showing a Dwarfed Right

Auricle 23

17. Lateral View of the Heart of a Fish 26

18. Ventral View of the Heart of Necturus 27

19. Dorsal View of the Heart of a Black Snake 28

20. Anterior View of the Base of the Ventricles of the

Sheep Heart after the Auricles have been Completely

Removed 29

CHAPTER I

THE PROBLEM

There were three purposes for this study. The first purpose was to determine the normal anatomy of the major structures of the heart of Rana pipiens. The second purpose was to determine if any variations or anomalies existed in these structures. The third purpose was to determine if any similarity existed between any variations found and the hearts of other animals.

The normal anatomy of the frog heart, as described in most books, is either incomplete, wrong, or applies to species other than Rana pipiens. In no case was there an adequate description found of the heart as possessed by Rana pipiens. For this reason, a study of the anatomy of the heart of Rana pipiens is important.

In the evolution and development of the frog, there are so many factors involved that none of the frogs has a definite or set anatomy. On the contrary, some measure of variation occurs in every animal. This study dealt only with the gross variations in the major structures of the heart and did not include a microscopic examination or an examination of the minor structures, such as the valves.

The importance of similarities of structures of different species of animals in the study of evolution is very great. To show that a variation of a structure has a similarity to the corresponding structure in another species may indicate a genetic relationship between the two. Variations may show the trends of evolution or may show regressions to more primitive conditions. Sometimes, however, they are simply abnormalities in the development of the individual animal.

CHAPTER II

THE MATERIAL AND PROCEDURE

The only species of frog used in this study was Rana pipiens.

In his book, Amphibia and Reptiles, Hans Gadow states that the genus Rana has the following characteristics: horizontal pupil; tongue deeply notched and free behind; vomers with teeth; fingers free; toes webbed and fourth and fifth metatarsals diverging and webbed together.

Mary Dickerson, in The Frog Book, says that Rana pipiens is characterized by the following: male between three and four inches long with the female larger; webs deeply indented; tubercles under joints of toes are prominent; inner sole tubercle is small, and no outer tubercle.

Dickerson also says that Rana pipiens is distinguished from Rana sphenoccephala, its nearest relative, by Rana sphenoccephala having a longer and more pointed nose and also much longer hind legs.

One hundred and twenty-five frogs were used which were obtained from E. Steinhilber, Oshkosh, Wisconsin. This supplier secured them from Winnebago County, Wisconsin.

The heart of each frog was examined for variations in the following structures: conus arteriosus; sinus venosus and caval veins; sinu-auricular aperture; interauricular septum; auriculo-ventricular aperture; ventricular septum (if present), and any other variation that might be apparent.

Alexander Ecker, in his Anatomy of the Frog, lists three variations that have been reported to exist in the interauricular septum. Three variations are: incomplete septum; septum absent, and septum so far to

the left that it appears to be absent.

No ventricular septum normally occurs in the frog heart, but it was part of this study to see if one did occur as a variation, either a complete one or an incomplete one.

In the dissection, the ventral wall of the frog's body was first cut away to expose the heart. The heart was next removed intact and placed in a small dish of water and kept under water during the entire examination so that the water would buoy up the structures. The water would get dirty because of the blood from the heart and would have to be changed frequently. The pericardium and other tissues were cleared from the heart, which was then examined for variations in the conus arteriosus, sinus venosus and caval veins. Part of the sinus venosus was next dissected away in order that the sinu-auricular aperture could be seen. Portions of the walls of the auricles were then cut away in such a manner that the interauricular septum could be seen but would not be damaged. The blood was thoroughly washed out of the two auricles and then the interauricular septum was examined for variations. The top portion of the auricles were then removed so as to give a good view of the auriculo-ventricular aperture. The ventricle was then cut transversely into two halves so that it could be examined for a ventricular septum.

A hand lens and binocular microscope were used on some of the hearts, but most of the work was done with the unaided eye.

In the majority of cases, after each heart had been dissected, the pieces were tagged and labeled and kept in formaldehyde until after all of the hearts had been dissected, then they were re-examined to make

comparisons of the different hearts.

CHAPTER III

THE NORMAL ANATOMY OF THE HEART

The normal anatomy of the heart of Rana pipiens, as presented in this thesis, is based on dissections.

The heart of Rana pipiens is located in the median region of the body below the esophagus. The apex of the heart is directed posteriorly and lies between the lobes of the liver. The anterior end or base of the heart lies a short distance behind the larynx. The pericardium surrounds the heart.

The ventral view of the heart is shown in Figure 1. There are two auricles and they are located in front of the ventricle. The right auricle is much larger than the left one. Externally, the longitudinal sulcus separates the two auricles and the coronary sulcus separates the auricles from the ventricle. The conus arteriosus runs obliquely across the right auricle. It goes into the truncus arteriosus which gives off two trunks.

The conus arteriosus normally does not arise from the ventral surface of the base of the ventricle as some authorities say, or, at least, it does not arise in that position in Rana pipiens. The most prominent authority to assume that it does arise from the ventral surface is Ecker (1889). In Rana pipiens, the conus arteriosus normally arises from the dorsal surface, as can be seen in Figure 2. In Figure 3, the conus arteriosus can be seen passing from the dorsal to the ventral surface. No authority was found who gave an adequate description of this.

In Figure 2, the sinus venosus is seen to be in a median location

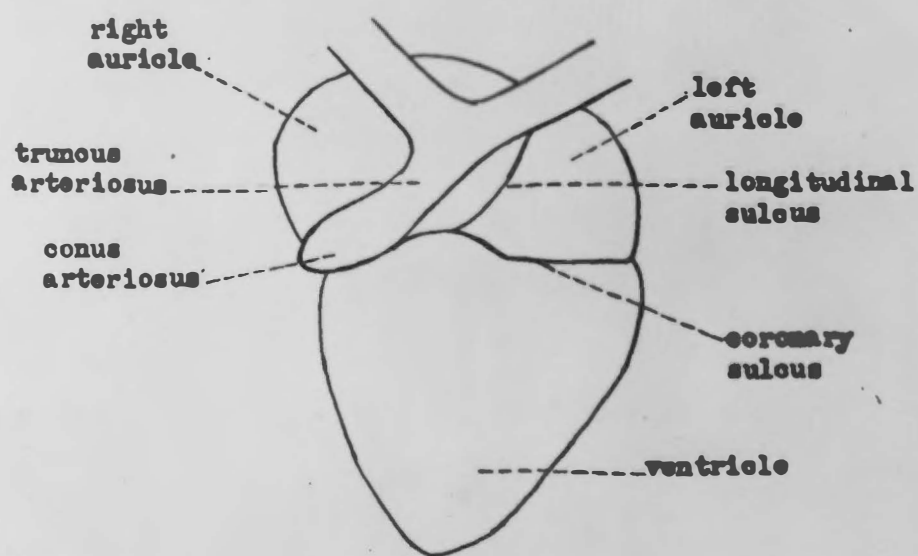


Fig. 1 - Ventral view of the frog heart.

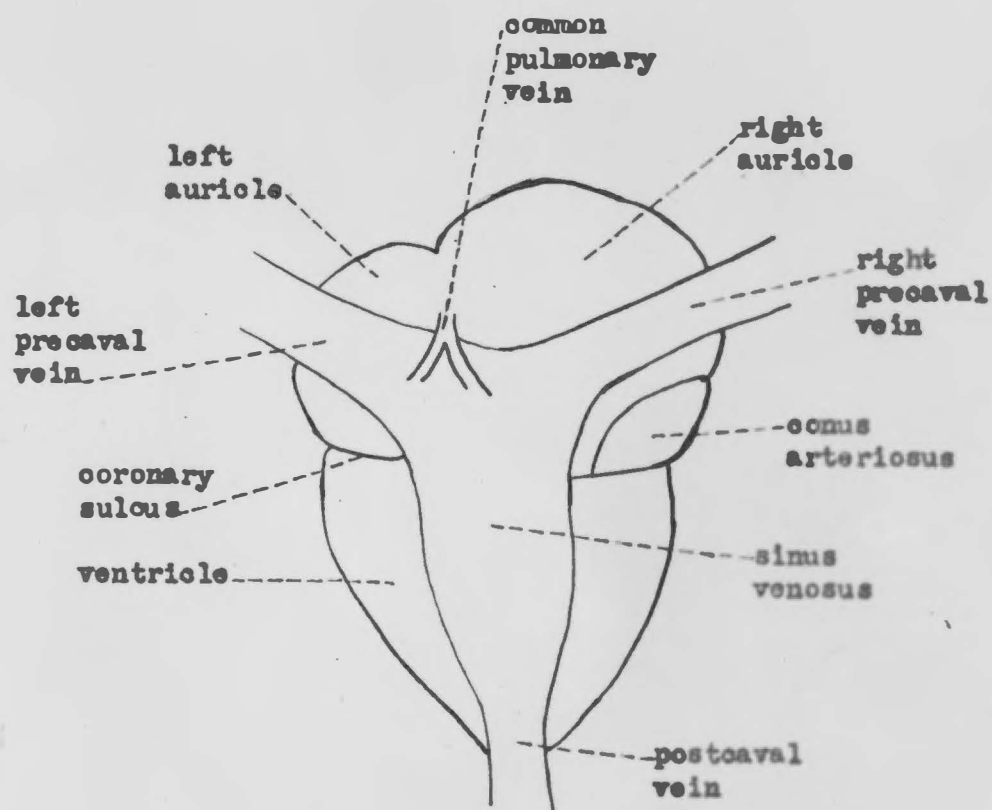


Fig. 2 - Dorsal view of the frog heart.

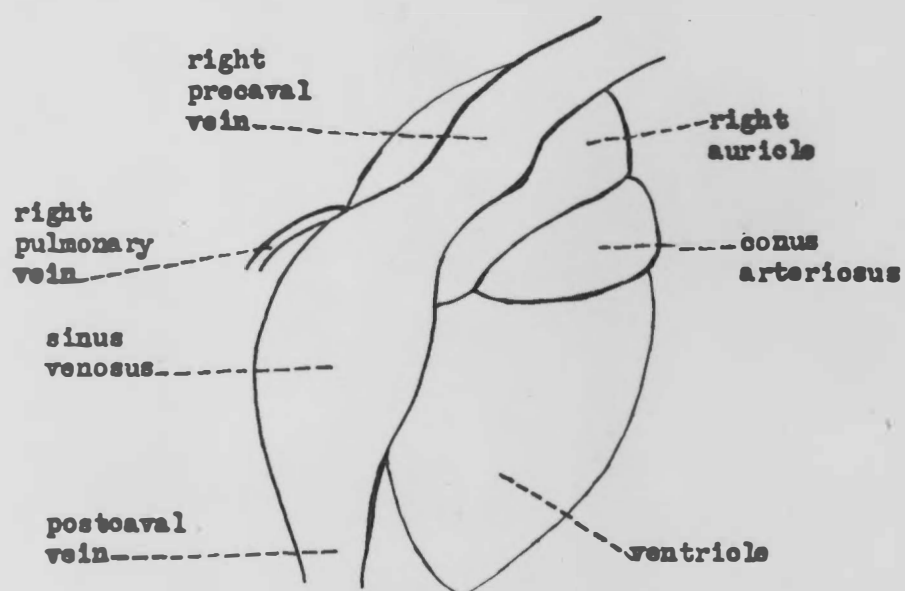


Fig. 3 - View of the right
side of the frog heart.

on the dorsal surface of the heart. The two anterior blood vessels leading to it are the right and left precaval veins, and the posterior vessel is the postcaval vein. The common pulmonary vein is formed by the right and left pulmonary veins which come from the lungs. The common pulmonary vein empties into the left auricle anterior to the sinus venosus.

In Figure 3, the parts of the heart can be seen in their relative position on the right side.

Figure 4 shows the location of the sinu-auricular aperture which connects the sinus venosus with the right auricle.

Figures 5, 6 and 7 show the location of the internal structures of the heart. The interauricular septum separates the two auricles and has a free border as it passes over the single auriculo-ventricular aperture. The sinus venosus empties into the right auricle and the pulmonary vein empties into the left auricle.

The inner surface of the ventricle has muscular ridges called trabeculae. The wall of the ventricle is much thicker than that of the auricles.

Figure 8 shows the location of the origin of the conus arteriosus and the auriculo-ventricular aperture.

The best and most complete description of the sinus venosus, caval veins, pulmonary veins, and the internal structures of the heart was found in Ecker's book, which has already been mentioned. In this book, the descriptions of the above structures correspond to the findings made during the dissections. Other books which have good descriptions of the anatomy of the frog heart are listed in the bibliography.

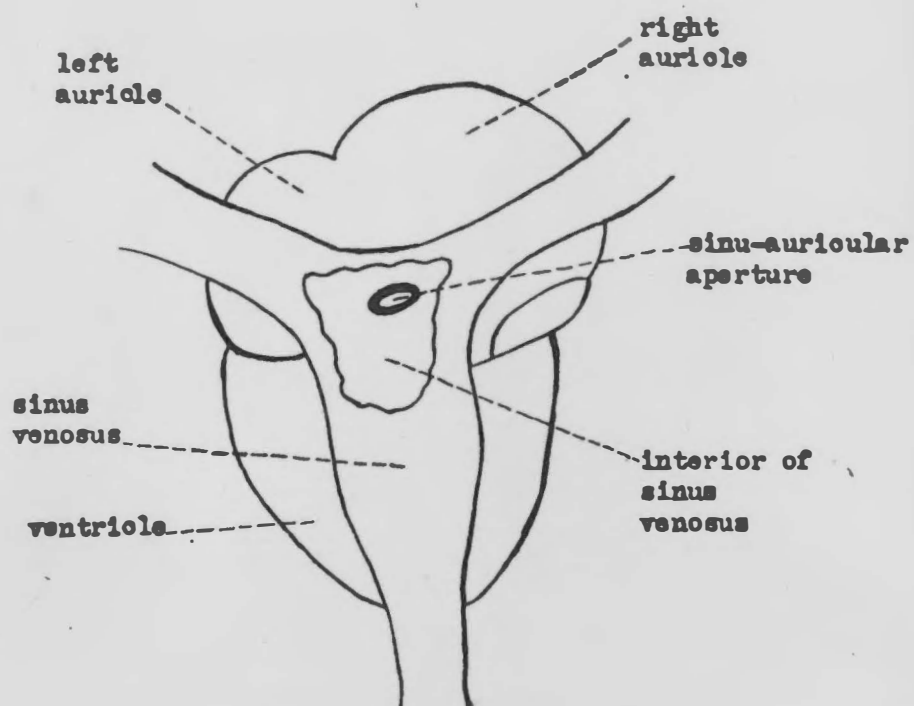


Fig. 4 - Dorsal view of the frog heart with part of the wall of the sinus venosus removed.

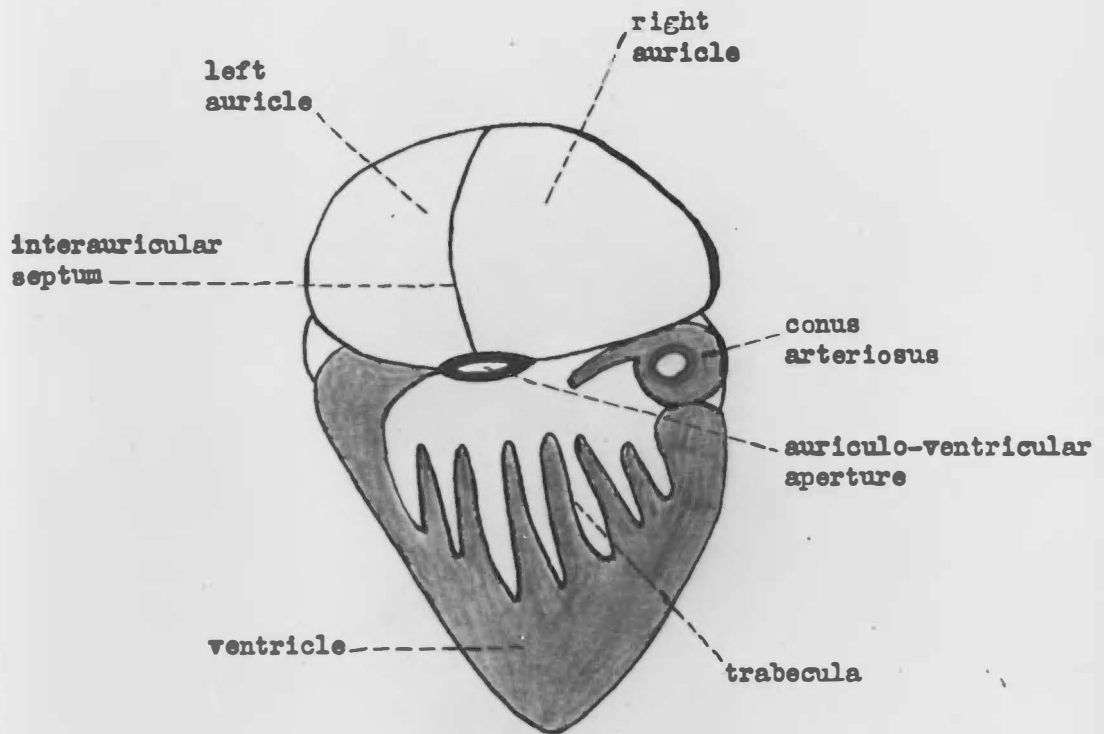


Fig. 5 - View of the ventral half of the frog heart.

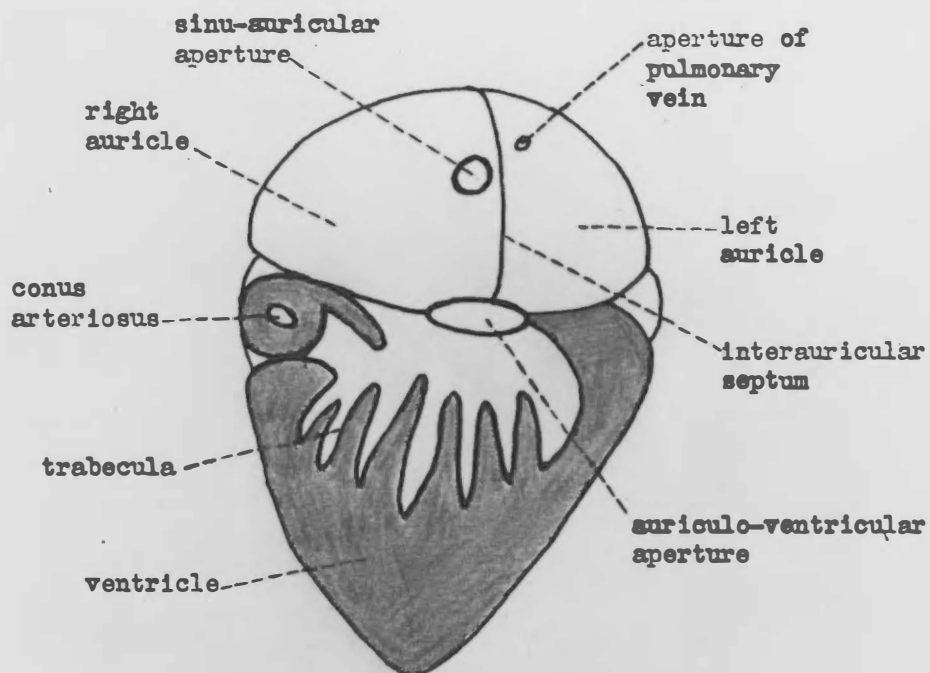


Fig. 6 - View of the dorsal half of the frog heart.

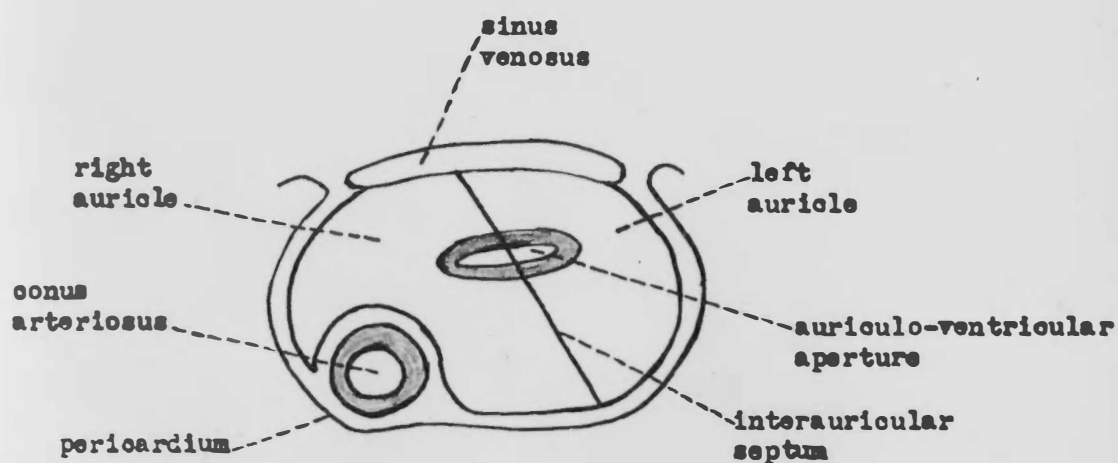


Fig. 7 - Anterior view of the frog heart with part of the auricles cut away.

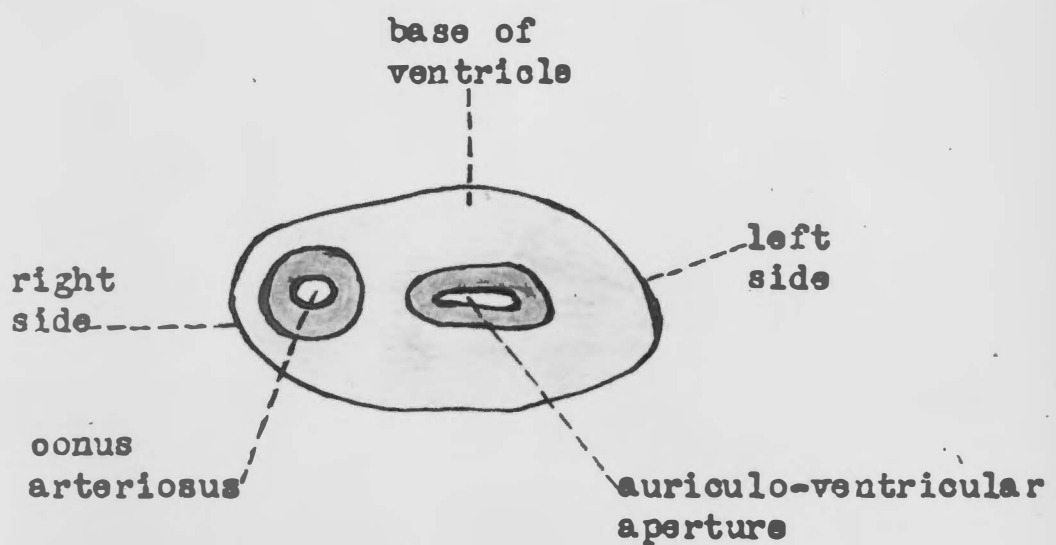


Fig. 8 - Anterior view of the frog heart with the auricles completely removed.

CHAPTER IV

THE VARIATIONS FOUND

The first variation to be noticed was a heart with a ventral origin of the conus arteriosus. See Figures 9, 10 and 11 for views of this. There was a total of three variations of this type in the hundred and twenty-five frogs.

The second type of variation seen was a heart with the sinus venosus in a position far to the right. The sinu-auricular aperture had a corresponding position to the right. See Figure 12. There was a total of five variations of this type.

The next variation was a heart with the interauricular septum to the left. The left auricle was only about one-half or two-thirds the size of a normal one and the right auricle was consequently larger because of the position of the septum. Both the sinus venosus and the pulmonary vein emptied into the right auricle. There was no apparent perforation of the septum and it seemed to be complete in every way. Figures 13 and 14 show this variation. Only one variation of this type was found.

Another variation was a heart with two auriculo-ventricular apertures. The two apertures were close together but they were definitely separated. Figure 15 shows this variation. There were two hearts found with this variation.

The last type of variation found was a heart with a very small right auricle. The right auricle was approximately the size of the left one. This dwarfed right auricle is seen in Figure 16. Only one varia-

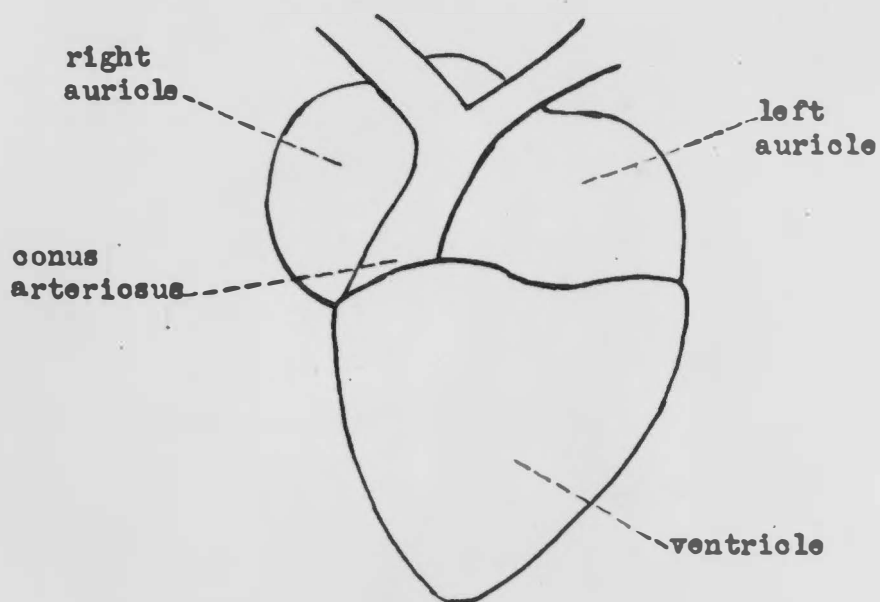


Fig. 9 - Ventral view of the frog heart showing a more ventral origin of the conus arteriosus than is normal.

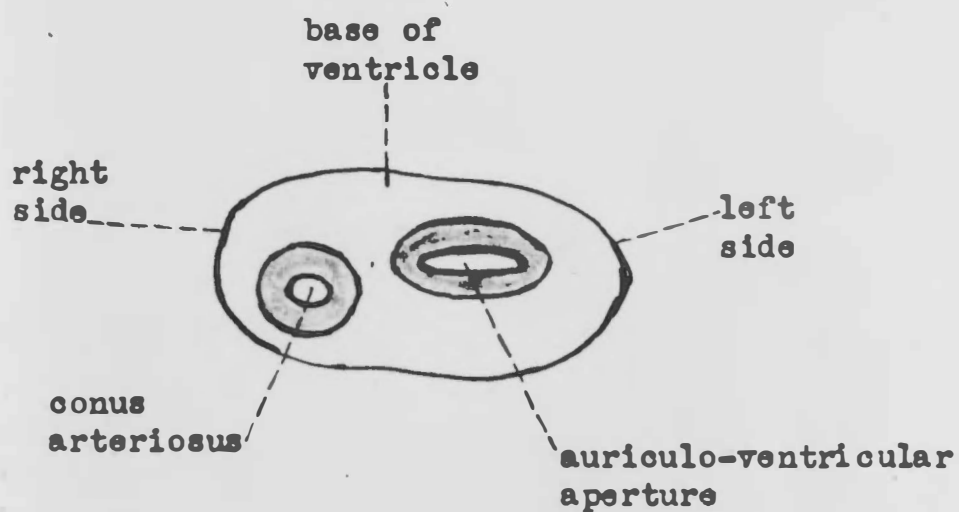


Fig. 10 - Anterior view of a frog heart with the auricles completely removed. Shows a more ventral origin of the conus arteriosus than is normal.

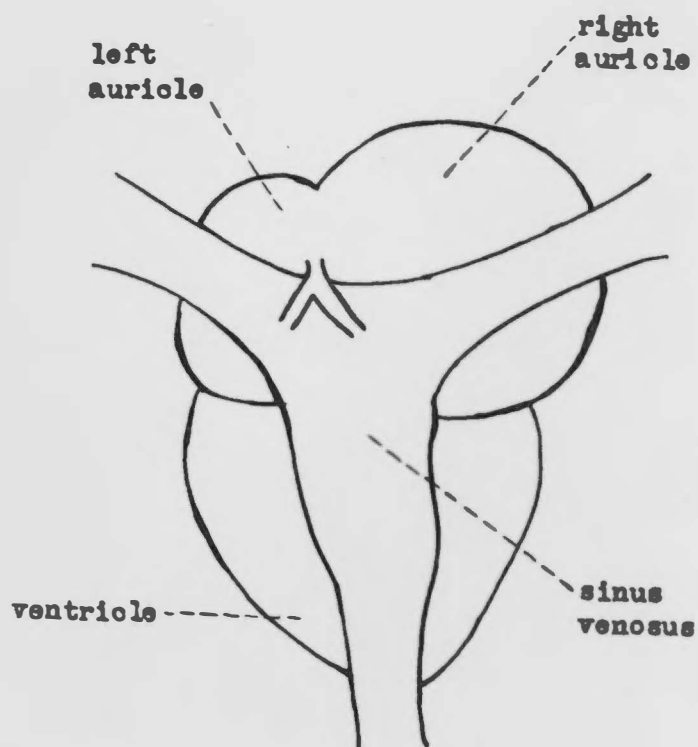


Fig. 11 - Dorsal view of a frog heart showing lack of conus arteriosus on the dorsal surface when its origin is in a ventral position.

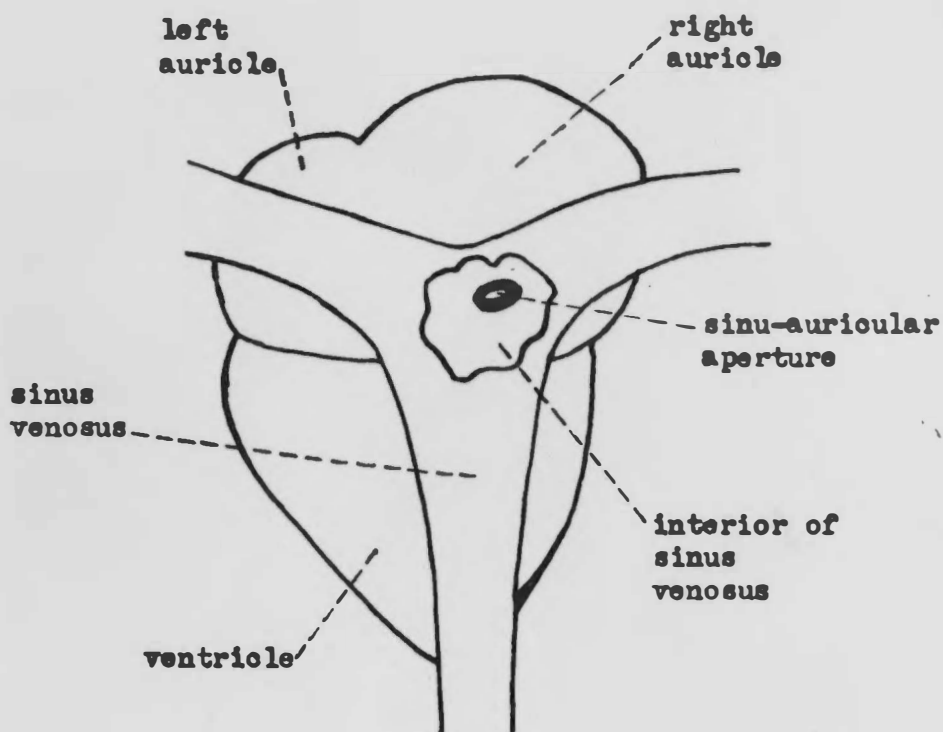


Fig. 12 - Dorsal view of a frog heart with part of the wall of the sinus venosus removed. Shows the abnormal position to the right of the sinus venosus and sinu-auricular aperture.

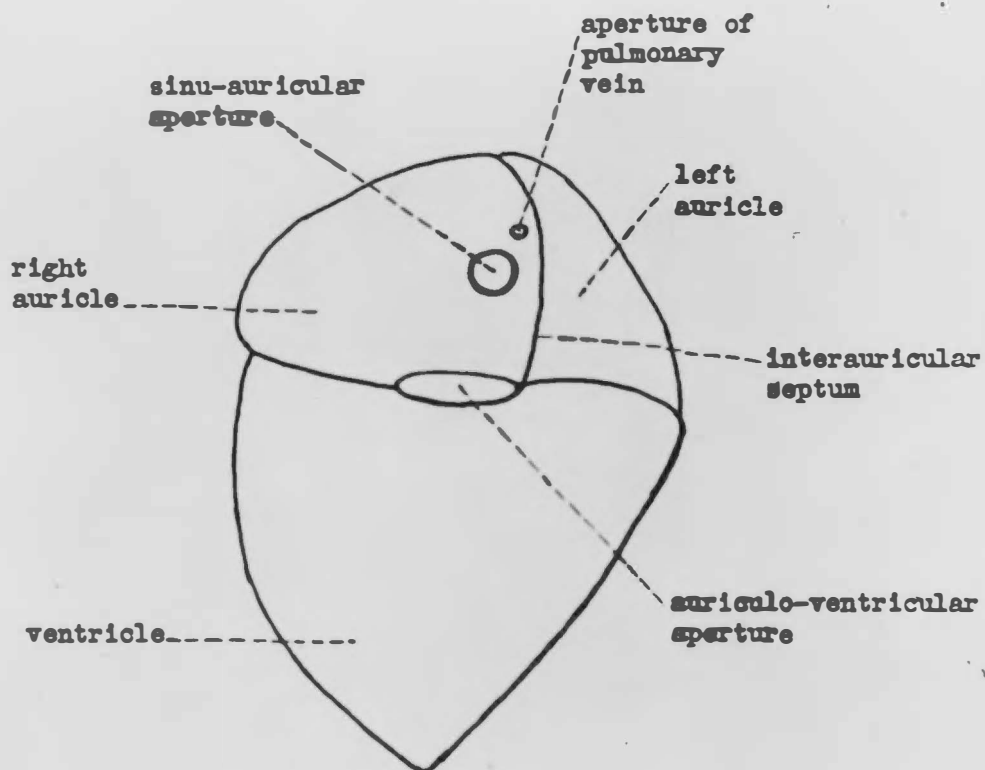


Fig. 13 - View of the dorsal half of a frog heart. Shows the interauricular septum in a position more to the left than is normal.

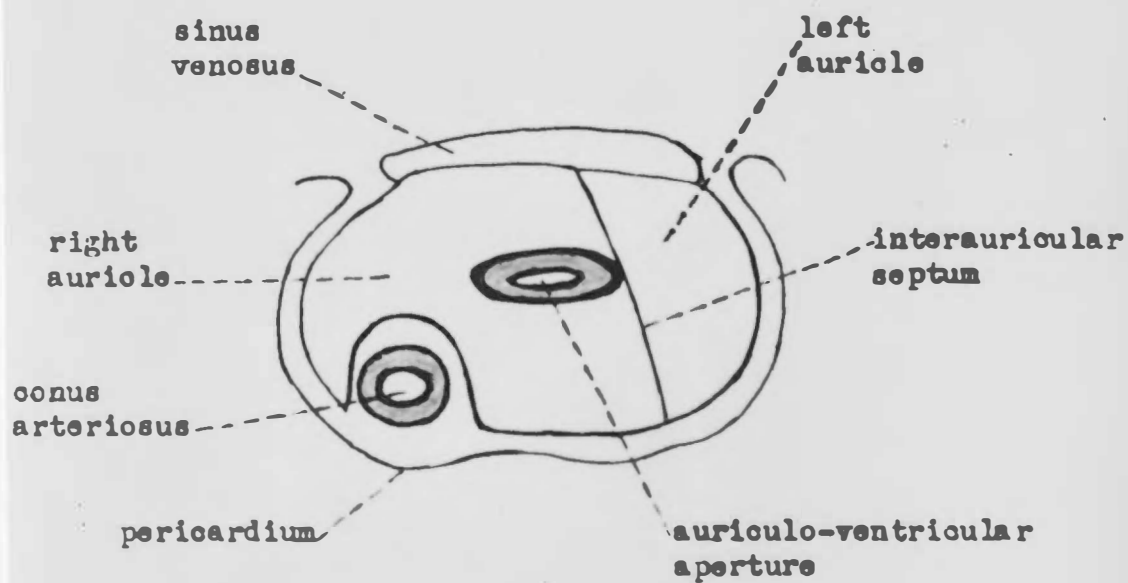


Fig. 14 - Anterior view of a frog heart with part of the aurioles cut away. Shows the interauricular septum in a position more to the left than is normal.

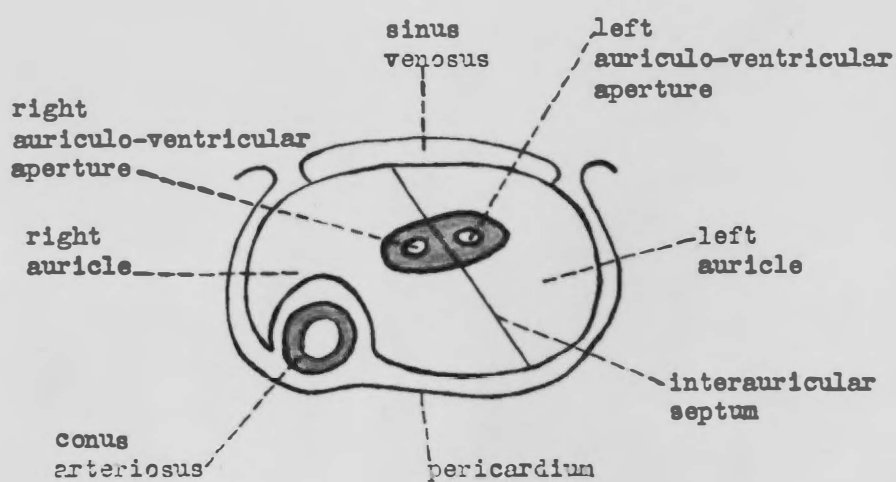


Fig. 15 - Anterior view of a frog heart with part of the auricles cut away. Shows two auriculo-ventricular apertures.

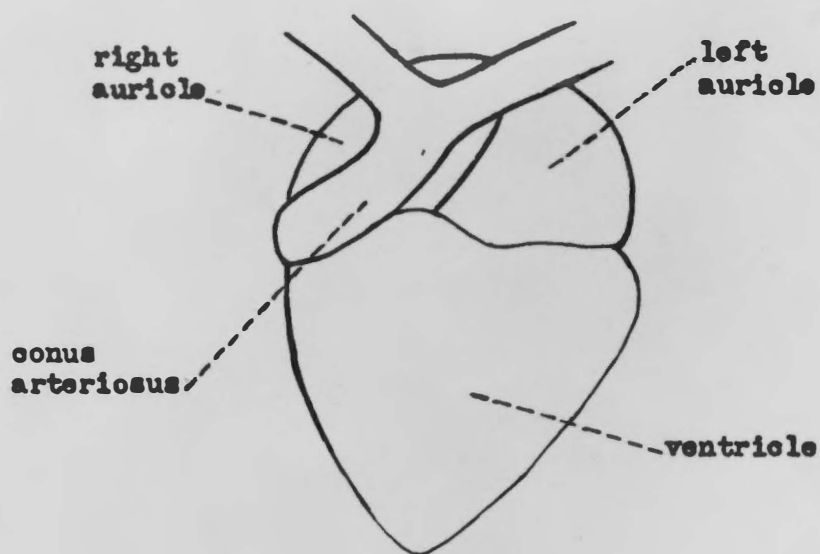


**Fig. 16 - Ventral view of a frog heart
showing a dwarfed right auricle.**

tion of this type was found. The relationship of the sinu-auricular aperture and the aperture of the pulmonary vein to the interauricular septum was the same as in a normal heart. There was no change in this relationship as was seen in the variation with the enlarged right auricle.

There were no hearts with absent or incomplete interauricular septa. No heart was found with the interauricular septum to the left so far that it appeared to be absent. Also, no heart was found with either a complete or incomplete ventricular septum.

CHAPTER V

DISCUSSION OF THE VARIATIONS FOUND

The purpose now is to compare the variations to the generalized forms found in other major vertebrate groups. The fish heart, the Necturus heart, the snake heart, and the sheep heart are used as specific examples of these other major types of vertebrate hearts. The above hearts are used as specific examples because I have made dissections of these hearts rather recently and am more familiar with them than the hearts of other animals. Dissections and drawings of the various aspects of these hearts were made in the Spring of 1947. Figures 17, 18, 19 and 20 are copies of drawings made from these dissections.

A frog heart with the interauricular septum to the left, as in the variation found, is structurally similar to a fish heart, but functionally it is different. In the fish heart, the aerated blood and non-aerated blood are not mixed, but in this type of frog heart the two types of blood are mixed. Compare Figures 13 and 17.

The fish heart shown in Figure 17 was drawn from an unidentified species caught in Cumberland River, Russell County, Kentucky. There are good illustrations and a good discussion of the fish heart in An Introduction to Animal Biology by John B. Parker.

A frog heart that has the conus arteriosus with a ventral origin is similar to the condition found in the generalized urodele heart, which is represented here by the Necturus heart. Compare Figures 9 and 18.

A good description of the heart of Necturus is in Comparative Vertebrate Anatomy by Libbie H. Hyman. Accurate illustrations of the ventral view of the heart of Necturus may be found in An Introduction

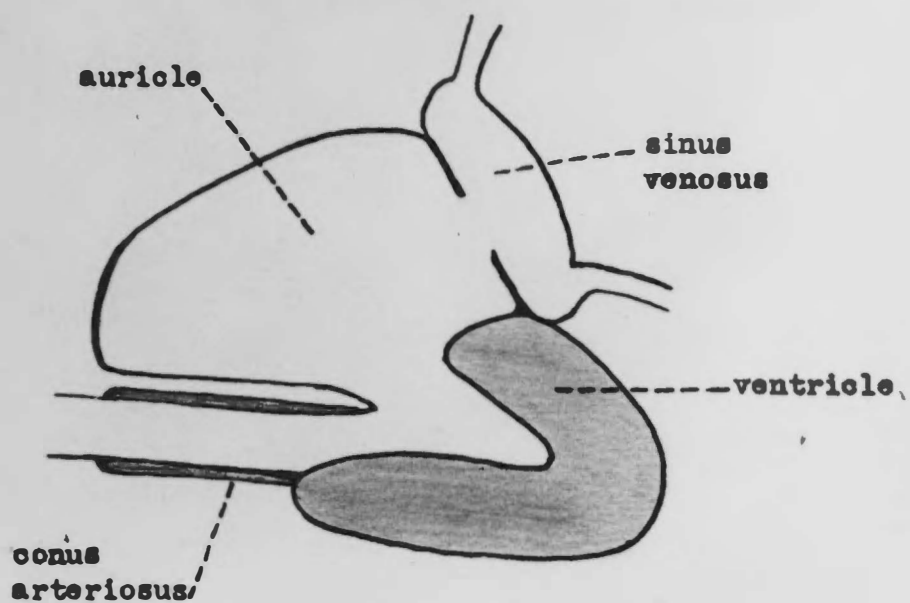


**Fig. 17 - Lateral view of the heart of a fish.
Shows a two-chambered heart.**

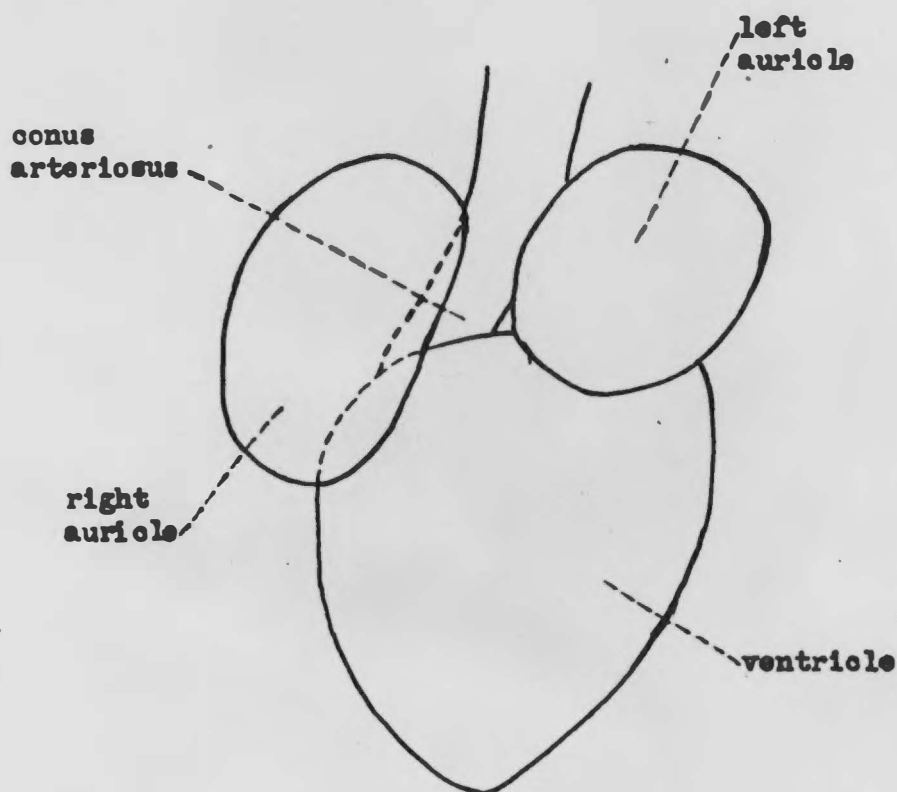


Fig. 18 - Ventral view of the heart of Necturus. The broken lines in the drawings represent the parts of the conus arteriosus and ventricle covered by the lobe-like part of the right auricle. Shows the origin of the conus arteriosus to be on a ventral aspect and on the right side of the base of the ventricle.

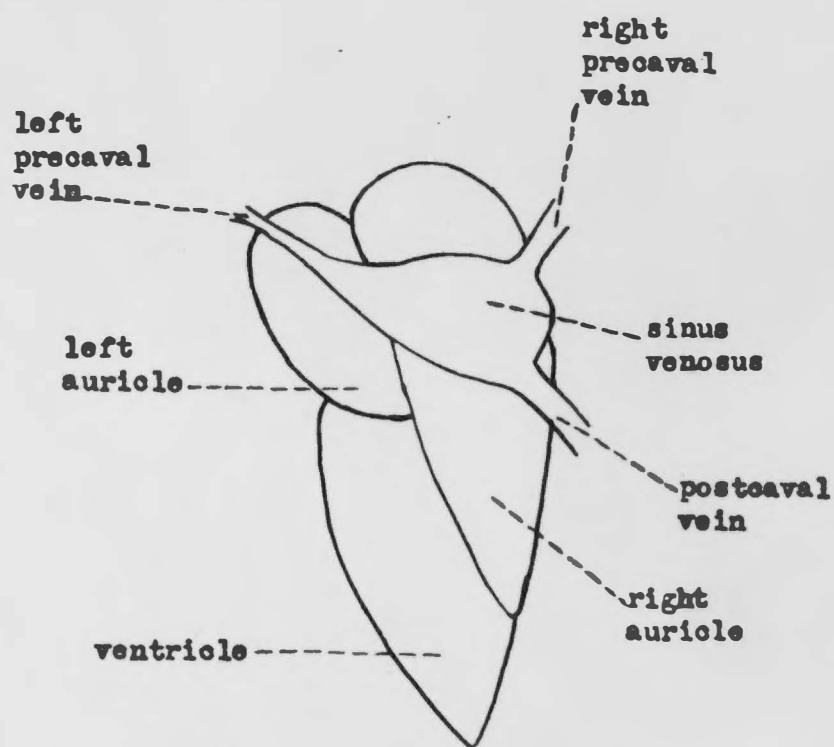


Fig. 19 - Dorsal view of the heart of a black snake. Shows the location of the sinus venosus.

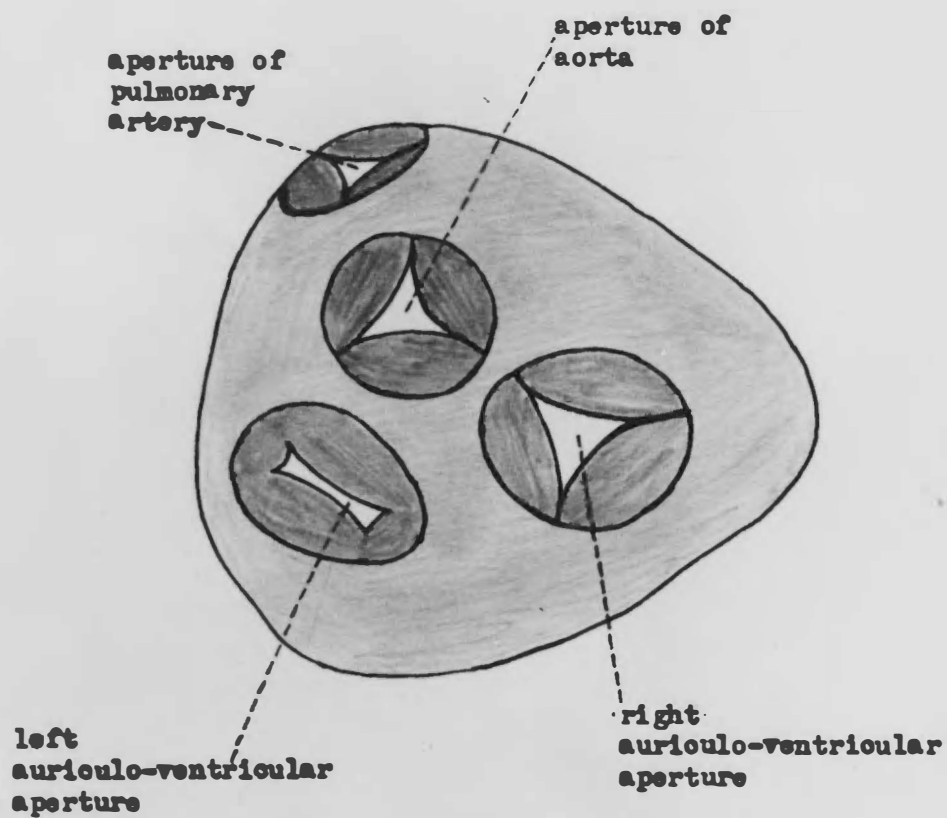


Fig. 20 - Anterior view of the base of the ventricles of the sheep heart after the auricles have been completely removed. Shows two auriculo-ventricular apertures.

to Vertebrate Anatomy by Harold M. Messer.

A frog heart with the sinus venosus on the right is similar to the condition found in the generalized three-chambered reptilian heart, which is represented here by the heart of a black snake. Compare Figures 12 and 19.

The three-chambered reptilian heart is discussed and well illustrated in Zootomy by T. Jeffery Parker.

A frog heart with two auriculo-ventricular apertures is similar to the normal condition found in the mammalian heart, which is represented here by the heart of the sheep. Compare Figures 15 and 20.

The mammalian heart is well discussed and illustrated in Henry Gray's Anatomy of the Human Body.

A frog heart with a dwarfed right auricle would probably have to be considered the result of abnormal development and not be considered similar to the heart of any other animal.

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