

at least as the very strongest probability, that their hearts are ancestrally represented in the hearts of lower forms; if so, then plainly the study of the mammalian heart should begin with that of antecedent and simpler developments.

I hope to be able to show that the researches of the last few years have not only thrown a flood of light on cardiac physiology and anatomy in general, but brought us incomparably nearer to a correct appreciation of the complex workings of the mammalian heart itself than we were even three years ago.

The work for the mammalian heart along the new lines of departure in investigation is still in great part to be done. The problem I wish especially to attack in this paper is the cause, or rather causes, of the heart-beat. These have now been fairly well determined for the lower vertebrates. In the light thus afforded, what may we consider as the probable solution of the question for the mammalian heart? The study of this problem will involve, incidentally, that of many others.

When one considers the evolution of the heart morphologically, we are brought back to its beginnings, in connection at least with a nutritive fluid, in contractile tubes, as in the worms among invertebrates; and it would appear that most, if not all, kinds of hearts may be considered as dilations and differentiations of this simple form of pulsatile organ.

Passing by the pulsating vacuoles of the Infusorians as of doubtful significance, the contractile tube seems to be the primitive representative of the heart; and it is very significant that the earliest form of the heart in the embryo of the highest vertebrates is a pulsating tube, the after-changes in which give an epitomized history, to a large extent we may suppose, of the evolution of the vertebrate heart from lower forms.

Moreover, in that lowest of fishes (?), the *Amphioxus*, the heart is represented by pulsatile vessels. Now in these pulsatile tubes, so far as I know, nervous elements have not been found. The heart of the chick beats on the second day of incubation, when no nervous structures are to be found in it any more than in an *Amoeba*.

Englemann has shown that in the ureter (or a portion of it),