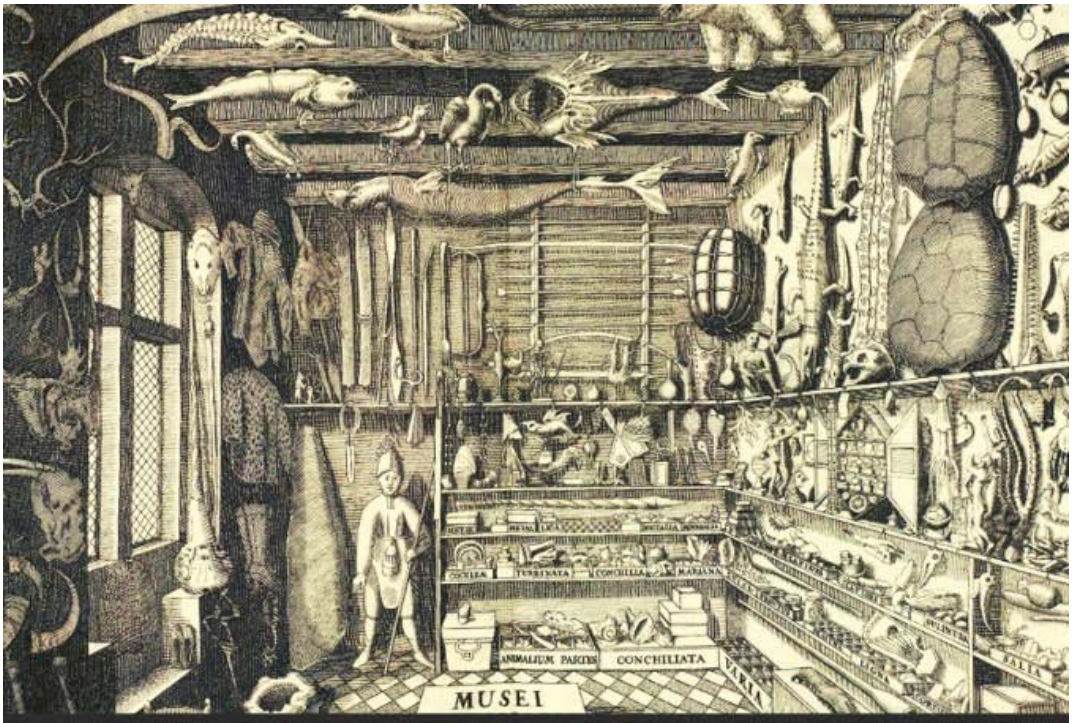

FATHERS OF BIOLOGY

CHARLES MCRAE

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Fathers of Biology by Charles McRae.

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(2) That one kind of blood was thought to flow from the liver to the right ventricle, and thence to the lungs and general system by the veins, while another kind flowed from the left ventricle to the lungs and general system by the arteries;

(3) That the septum of the heart was regarded as admitting of the passage of blood directly from the right to the left side;

(4) That there was no conception of the functions of the heart as the motor power of the movement of the blood, for biologists of that day doubted whether the substance of the heart were really muscular; they supposed the pulsations to be due to expansion of the spirits it contained; they believed the only dynamic effect which it had on the blood to be that of sucking it in during its active diastole, and they supposed the chief use of its constant movements to be the due mixture of blood and spirits.

This was the state of knowledge before Harvey's time. By his great work he established —

(1) That the blood flows continuously in a circuit through the whole body, the force propelling it in this unwearied round being the rhythmical contractions of the muscular walls of the heart;

(2) That a portion only of the blood is expended in nutrition each time that it circulates;

(3) That the blood conveyed in the systemic arteries communicates heat as well as nourishment throughout the body, instead of exerting a cooling influence, as was vulgarly supposed; and

(4) That the pulse is not produced by the arteries enlarging and so filling, but by the arteries being filled with blood and so enlarging.

We can now consider the method by which Harvey arrived at these results. The work, "De Motu Cordis et Sanguinis," after giving an account of the views of preceding physiologists, ancient and modern, commences with a description of the heart as seen in a living animal when the chest has been laid open and the pericardium removed. Three circumstances are noted —

(*a*) The heart becomes erect, strikes the chest, and gives a beat;

(*b*) It is constricted in every direction;

(*c*) Grasped by the hand, it is felt to become harder during the contraction.

From these circumstances it is inferred —

(1) That the action of the heart is essentially of the same nature as that of voluntary muscles, which become hard and condensed when they act;

(2) That, as the effect of this, the capacity of the cavities is diminished, and the blood is expelled;

(3) That the intrinsic motion of the heart is the systole, and not the diastole, as previously imagined.

The motions of the arteries are next shown to be dependent upon the action of the heart, because the arteries are distended by the wave of blood that is thrown into them, being filled like sacs or bladders, and not expanding like bellows. These conclusions are confirmed by the jerking way in which blood flows from a cut artery.

In the heart itself two distinct motions are observed — first of the auricles, and then of the ventricles. These alternate contractions and dilatations can have but one result, namely, to force the blood from the auricle to the ventricle, and from the ventricle, on the right side, by the pulmonary artery to the lungs, and on the left side by the aorta to the system.

These considerations suggest to the mind of Harvey the idea of the circulation. "I began to think," he says, "whether there might not be a motion, as it were, in a circle." This is next established by proving the three following propositions:—

(1) The blood is incessantly transmitted by the action of the heart from the vena cava to the arteries in such quantity that it cannot be supplied from the ingesta, and in such wise that the whole mass must very quickly pass through the organ;

(2) The blood, under the influence of the arterial pulse, enters, and is impelled in a continuous, equable, and incessant stream through every part

and member of the body, in much larger quantity than were sufficient for nutrition, or than the whole mass of fluids could supply;

(3) The veins in like manner return this blood incessantly to the heart from all parts and members of the body.

As to the first proposition Harvey says, "Did the heart eject but two drachms of blood on each contraction, and the beats in half an hour were a thousand, the quantity expelled in that time would amount to twenty pounds and ten ounces; and were the quantity an ounce, it would be as much as eighty pounds and four ounces. Such quantities, it is certain, could not be supplied by any possible amount of meat and drink consumed within the time specified. It is the same blood, consequently, that is now flowing out by the arteries, now returning by the veins; and it is simply matter of necessity that the blood should perform a circuit, or return to the place from whence it went forth."

Demonstration of the second proposition — that the blood enters a limb by the arteries and returns from it by the veins — is afforded by the effects of a ligature. For if the upper part of the arm be *tightly* bound, the arteries below will not pulsate, while those above will throb violently. The hand under such circumstances will retain its natural colour and appearance, although, if the bandage be kept on for a minute or two, it will begin to look livid and to fall in temperature. But if the bandage be now slackened a little, the hand and the arm will immediately become suffused, and the superficial veins show themselves tumid and knotted, the pulse at the wrist in the same instant beginning to beat as it did before the application of the bandage. The tight bandage not only compresses the veins, but the arteries also, so that blood cannot flow through either. The slacker ligature obstructs the veins only, for the arteries lie deeper and have firmer coats. "Seeing, then," says Harvey, "that the moderately tight ligature renders the veins turgid, and the whole hand full of blood, I ask, Whence is this? Does the blood accumulate below the ligature coming through the veins, or through the arteries, or passing by certain secret pores? Through the veins it cannot come; still less can it come by any system of invisible pores; it must needs, then, arrive by the arteries."

The third position to be proved is that the veins return the blood to the heart from all parts of the body. That such is the case might be inferred from the presence and disposition of the valves in the veins; for the office of the valves is by no means explained by the theory that they are to hinder the blood from flowing into inferior parts by gravitation, since the valves do not always look upwards, but always towards the trunks of the veins, invariably towards the seat of the heart. The action of the valves is then demonstrated experimentally on the arm bound as for blood-letting. The point of a finger being kept on a vein, the blood from the space above may be streaked upwards till it passes the valve, when that portion of the vein between the valve and the point of pressure will not only be emptied of its contents, but will remain empty as long as the pressure is continued. If the pressure be now removed, the empty part of the vein will fill instantly and look as turgid as before.

Other confirmatory evidence is then added, e.g. the absorption of animal poisons and of medicines applied externally, the muscular structure of the heart and the necessary working of its valves.

William Harvey, the illustrious physiologist, anatomist, and physician, to whom this discovery is due, was the eldest son of a Kentish yeoman, and was born in April, 1578. At the age of ten he entered the Canterbury Grammar School, where he appears to have remained for some years. At sixteen he passed to Caius–Gonvil College, Cambridge, and three years afterwards took his B.A. degree and quitted the university. Like most students of medicine of that day, he found it necessary to seek the principal part of his professional education abroad. He travelled to Italy, selected Padua as his place of study, and there continued to reside for four years, having as one of his teachers the famous Fabricius of Aquapendente. On his return to England, in 1602, he took his doctor's degree at Cambridge, and entered on the practice of his profession.

In 1604 he joined the College of Physicians, and three years later was elected a Fellow of that learned body. Two years afterwards he applied for the post of physician to St. Bartholomew's Hospital; and his application being supported by letters of recommendation to the governor, from the king and

from the president of the College of Physicians, he was duly elected to the office in the same year, as soon as a vacancy occurred.

In 1615, when thirty-seven years of age, Harvey was chosen to deliver the lectures on surgery and anatomy to the College of Physicians, and it is possible that at this time he gave an exposition of his views on the circulation. He continued to lecture on the same subject for many years afterwards, although he did not publish his views until 1628, when they appeared in the work "De Motu Cordis."

Some few years after his appointment as lecturer to the college, he was chosen one of the physicians extraordinary to King James I., and about five or six years after the accession of Charles I. he became physician in ordinary to that unfortunate monarch. The physiologist's investigations seem to have interested King Charles, for he had several exhibitions made of the *punctum saliens* in the embryo chick, and also witnessed dissections from time to time.

When, in 1630, the young Duke of Lennox made a journey on the Continent, Harvey was chosen to travel with him, and probably remained abroad about two years. During this time Harvey most likely visited Venice. Of this tour the doctor speaks in the following terms in a letter written at the time: "I can only complayne that by the waye we could scarce see a dogg, crow, kite, raven, or any bird or any thing to anatomise; only sum few miserable poeple the reliques of the war and the plauge, where famine had made anatomies before I came."

Six years after this, in April, 1636, he accompanied the Earl of Arundel in his embassy to the emperor. Having to visit the principal cities of Germany, he was thus afforded an opportunity of meeting the leading biologists of the time, and at Nuremberg he probably met Caspar Hoffmann, and made that public demonstration of the circulation of the blood which he had promised in his letter dated from that city, and which convinced every one present except Hoffmann himself. Hollar, the artist, informs us that Harvey's enthusiasm in his search for specimens often led him into danger, and caused grave anxiety to the Earl of Arundel. "For he would still be making of excursions into the woods, making observations of strange trees, plants,

Fabricius had looked upon as a blemish, a scar left by a broken peduncle. Harvey described this little cicatricula as expanding under the influence of incubation into a wider structure, which he called the eye of the egg, and at the same time separating into a clear and transparent part, in which later on, according to him, there appeared, as the first rudiment of the embryo, the heart, or *punctum saliens*, together with the blood-vessels. He was clearly of opinion that the embryo arose by successive formation of parts out of the homogeneous and nearly liquid mass. This was the doctrine of epigenesis, which, notwithstanding its temporary overthrow by the erroneous theory of evolution,[20] is, with modifications, the doctrine now held.

Of Harvey's scholarship and culture we are not left in ignorance. Bishop Pearson, writing about seven years after the doctor's death, and Aubrey[21] have told us of his appreciation of the works of Aristotle, and in his own writings he refers more frequently to the Stagirite than to any other individual. Sir William Temple[22] has also put it on record that the famous Dr. Harvey was a great admirer of Virgil, whose works were frequently in his hands. His store of individual knowledge must have been great; and he seems never to have flagged in his anxiety to learn more. He made himself master of Oughtred's "Clavis Mathematica" in his old age, according to Aubrey, who found him "perusing it and working problems not long before he dyed."

Nor should it be forgotten that this illustrious physiologist and scholar was also the first English comparative anatomist. Of his knowledge of the lower animals he makes frequent use, and he says (in his work on the heart), "Had anatomists only been as conversant with the dissection of the lower animals as they are with that of the human body, many matters that have hitherto kept them in a perplexity of doubt, would, in my opinion, have met them freed from every kind of difficulty." Aubrey says that Harvey often told him "that of all the losses he sustained, no grief was so crucifying to him as the loss of his papers (containing notes of his dissections of the frog, toad, and

[20] According to the theory of evolution, the egg contained from the first an excessively minute, but complete animal, and the changes which took place during incubation consisted not in a formation of parts, but in a growth, *i.e.* in an expansion of the already existing embryo (see p. 40).
[21] See p. lxxxii. of "Life," by Dr. Willis.
[22] "Miscellanies:" Part II. on Poetry, p. 314.