History of an
Knowledge regarding the
Circulatory System

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[Stamp: Edinburgh University]
Illustrations of the Circulation
by Early Workers.

Epicurean (300 BC)

Achilles (200 BC)

Servetus (1583)

Fabricius ab Aquapendente 1576
Present Day Cardiac Illustrations

Left Section of Heart

Right Section of Heart

Network of Capillaries connecting Arteries with Veins
After a fairly comprehensive study of the evolution of knowledge regarding the Blood, its functions and mode of transit, one can recognize the early investigators only in very dim outline, and their discoveries seem shrouded in mystery.

With the march of civilization, however, the ideas and theories of thinkers become more pronounced, till the 17th Century sees Harvey's epoch-making discovery.

The cultivated Egyptians, the divine Hippocrates, the venerable philosophic Aristotle, the free-thinking Galen, the learned Churchmen, the martyrized Servetus, Celsus, or greatest of all, Harvey, richly deserve our tribute of gratitude, for the materials, however scant, each has brought to aid in the construction of the estimable Temple of Learning.

Of the remedial medicine of the aboriginal races, very little is known, and equally obscure are their therapeutic processes and anatomical and physiological knowledge. They seem, however, to have regarded the Blood as having been intrinsically woven into the causes of disease. Little or no efforts appear to have been made, however, to examine either the course or minute qualities of that marvelously-endowed fluid, although venesection was extensively practised, usually by means of a sharp flute.

More to known about the medicine of the Semarian, Babylonian, and Assyrian races. Concomitant with increase of knowledge, a desire began to manifest itself, to investigate and locate if possible certain psychological phenomena, and to define the undefinable Soul.
Amongst the Semitic peoples, the liver was considered to be the chief organ of the body and the seat of the soul, in addition to its being the central organ of the blood.

On the other hand, the Babylonians recognised the heart as being the seat of the understanding, although the blood was looked upon as being the vital active principle. Two kinds of blood were recognised, that which flowed during the day, corresponding to red arterial, and the second, answering to dark, venous blood, which was supposed to course through the bloodvessels in the night-time. With this race, the blood and in small measure, the body-juices, were the fundamental principle, and constituted the basis of life. This belief was founded on their curious myth of the Creation, wherein one of the deities was decapitated, and the gore of the unfortunate god, mingling with the earth, gave rise to vital processes.

Later on, about 700 B.C., magicians flourished in Babylonia and Assyria, and in their charlatanic doctrines, mental disorders were ascribed to the influence of demons, who took up their abode in the heart of the individual, and exercised their deleterious powers by means of the blood, till eventually the brain was affected. No attempts were made, however, to trace the paths by which such influences were supposed to travel to their final destinations.

When everything is considered, and arguments to the contrary are exhausted, the fact remains that from Egypt emanated the light of true medical science, the light which, in after years, was reflected by Greece and Rome, and given out as having been fundamentally set aglow in these latter centres of culture.
From the dim mists of Egyptian mythical history, scribes were recognised and selected as patrons and practitioners of the Healing Art. It is from the Papyrns Ebers, a compilation of medical facts, attributed ceremonially to Choth, the lunar deity, but probably the work grew aposthised physician I-em-Hotep, that we derive most of our knowledge of Pharaonic medicine. This I-em-Hotep, who flourished about 5000 B.C., was served by priests who performed many necropsies, and amongst other internal organs, the heart and great bloodvessels were removed and preserved. Some insight into the central part of the Circulatory System was thereby obtained, although dissections and further investigations on human beings were prohibited. The physicians and priests possessed a moderate degree of converseance with cardiac structure and action, and they attempted to formulate theories on the course of the blood. That the "medicine men" of the period were eager for fuller knowledge on the subject of the Circulation is delightfully illustrated in "Osirid" by Prof. Ebers, where we tell of the substitution of a sheep's heart in a corpse, in order that the physician might dissect the similar organ of a man. It occasions no surprise, that, in such a progressive race as the Egyptians, the paths by which pneumatic circulation took place, were fixed with "deceptive exactness" in the more remote times. As did the Greeks at a later period, the Egyptians, noticing that the arteries were amply filled with blood in the dead person, deduced the false conclusion, that a similar condition of affairs must hold in the living subject. The heart was recognised as being the seat of the bloodvessels and the following references to the circulatory System, taken from the Papyrns Ebers,
although vague, are yet, withal interesting.

"From the heart, vessels go to the whole body, and a finger laid on the head, neck, wrist, etc., recognizes the motion of the heart." (This, then, is a reference to the pulse.) "The heart is then known as the centre of all the vessels, of which go to the nasal chambers, 2 carrying mucus, and 2 blood; it proceed within the temples or skull, whence the ophthalmic vascular supply, and the 4 vessels divide inside the head and spread towards the hinder part."

Another portion of the same Papymos deals with the functions of the intra-cranial contents, and here we are able to recognize the progenitor of the slightly expanded Greek doctrine, which perhaps had here its source. "Breath enters the nostrils and penetrates to the heart and internal organs supplying the whole body abundantly. 3 vessels traverse the arms, extending to the fingers and a similar number to the legs, being distributed to the soles of the feet; 1 vessel to each testis, and 1 to each kidney; 4 vessels enter the liver, conveying fluid and air;" (probably the Hepatic Artery and Vein, Portal Vein, and bile duct). 4 channels convey fluid to the intestine and spleen, and two proceed to the bladder, whence urine secretion is produced; 4 carry fluid and air to the abdomen going to the right and left sides, and from them the urine secretion is formed." These latter represent seemingly the urine arteries and veins. This same Papymos contains yet another vague and fantastic schema of the circulation, the outcome of investigations by Eshnunna. The author identifies 12 vessels proceeding from the heart, of which 2 go to thoracic contents; 2 to each
arm, 2 to each leg, 2 to the back, and 2 to the front of the head; 2 branches proceed to the nose; 2 go to the right ear — "the breath of life goes through them," and 2 terminate in the left ear — "the breath of death goes through them."

In both the Papyri of Ebers and I.Brunn, are descriptions of air-vessels, the oldest source of the pneumatic theory. The Egyptians also made a distinction between good air, or that of life, and bad air, or that of death, which circulated differently, and these could hardly be explained otherwise than by the terms inspired and expired air, respectively.

The heart and stomach were supposed to constitute a double system — they were designated by the same hieroglyph, the wearing-pur — in which, the blood was prepared from ingested food. The Splanic doctrine, by the way, bears a close connection to this early theory. The heart was spoken of as being filled with blood, which came, or flowed, from it again, and was supposed to deteriorate and become smaller with age.

In one of the Papyri, after a description of symptoms, the statement is made that the patient is short of breath, "as the blood has stagnated, and doesn't circulate." This last word has here, much the same vague, undefined significance as Hippocrates' periodos stagnantos (circulation of the blood), which implies, although a subsequent explanation belies it, a current.

To sum up, we gather that the Egyptians, like the Greeks, knew that the blood flowed from the heart, but they never realized the pumping force of that organ, or the significant existence of the valves. They misconceived that they had attained to a full and accurate knowledge of the circulation, whilst they were yet, merely on the threshold of the Truth.

Primitiv...
In the Aryan-Hindu race the repression of dissection was all too heavily felt. Religious interdiction was placed on operations, involving contact with a corpse, and consequently anatomical research was stunted at its birth and rendered impracticable to pursue. The result was that speculative theories were advanced, instead of practical facts being taught, and briefly, Indian anatomy was simply a classification of constituent parts of the body. The data vary and accounts disagree with regard to the enumeration of the blood-vessels. In one place, 300 veins, radiating from the navel, are mentioned; in another 10 chief vessels are supposed to radiate from the heart. Blood-vessels, nerves, and vessel-canals were confounded indiscriminately, as was the case with the ancient Egyptians. Chyle, from the products of digestion, which took place through internal fire, flowed by 24 channels from the heart through the whole body, and this was supposed to change every five days into 60 other "primary constituents" of the body, the last-produced being blood, till at length semen was evolved. The quintessence of all the substances in this process, constituted the Vital Force which, conceived as a thin oily fluid, permeated the system and regulated the body functions.

Equally ill-defined, and even more preposterous, was the ancient Chinese and Japanese medicine. As Neubürger says, it was "a marvel of formalism, a caricature of real science, the main ideas being derived from the grandiose Chinese Natural Philosophy." As in Indian Medicine, the feelings of the priests and religious
the heart was considered to be a reflection of the state of Nature. A so-called male principle, vital warmth, along with a female principle, elemental moisture, were supposed to circulate together, with the blood and vital air, and were led by vessels of the vascular system to all parts of the body. The chief veins were variously divided, of which 6 contained the "positive element," primitive warmth, and 6, the "negative element," primitive moisture, and these veins partly began and partly ended in the feet and hands. Their circulatory arrangement was completed by 2 main collecting channels of which one, coursing at the back of the body, contained the positive and the other running in front lodged the negative element. The 12 veins had 23 branches, according to which were a great number of smaller vessels. "Chinese physiology supposes a circulation of blood and vital air, and asserts that in 24 hours, 50 circuits occur; during a respiration, blood and air travel 6 miles." That is, one complete circuit measured 168 feet, which distance was accomplished in half-an-hour. It is interesting to know that in the Chinese opinion also, the heart received the chyle, and transformed it into blood, and that the cardiac assistant, the small intestine, retransformed the blood into chyle again. The lungs allowed the blood to circulate and purified it from phlegm, their assistant, the large intestine, ridding course and
Thus far, we have seen how the advance of Medical Science was retarded by pedantry, superstition, and bigotry; we now turn to a wider field—the Fraxinus—which, in its day, offered ample scope for the furtherment of anatomical and physiological research. Philosophers, Aristotelian Temple, and physicians proper represented the types of medical development in ancient Greece.

The first-named, amongst other studies, gave much attention to the science of Medicine, and anatomical knowledge of no mean sort formed part of their philosophical equipment. This age may truly be styled, "The Commencement of Medical Theory," for amongst others, Thales of Miletus, who flourished about 585 B.C., Alcmaeon, Pythagoras, Anaximenes, Empedocles, etc., strove to make a breach in the solid wall of mythical problems, and to accomplish this task, they first attempted to render in simple fashion, the organs and systems of the body, and to state the connection of the latter with the former.

Taking the Vascular System as a sample, let us see how a few of the more famous sophists of the time treated this subject.

The blood was regarded till about 350 B.C. as the means of sensory communication, and, although Alcmaeon of Croton, originated the view that "the brain was the common sensum," still, the functions of the cranial nerves were not recognized by him.

The so-called "normal" pathology of Hippocrates was initiated by Philolaus, a pupil of Pythagoras, who considered that the causes of disease were to be found in disorders of blood, bile, and phlegm.

Empedocles again, thought that flesh and blood contained equal
parts of the four elements, which were to be identified with heat, cold, moisture and dryness. The heart, he suggested, in addition to being the first structure formed in the embryo, was the centre of consciousness, (cf. this with the Egyptian doctrine and with that of the Copt School). He also imagined that "bloodless tubes of flesh," extended over the surface of the body, at the mouths of which, the outermost part of the skin was perforated over with closely packed pores, so as to keep in the blood, whilst thus, a free air-passage was ensured. When the thin blood, the carrier and seal of animal warmth, that surged through the limbs, rushed back to the interior, the stream of air came in with a rushing sound; but on the return of the sanguine fluid, the air expired again in equal quantity. The sea of blood, where was "what men call'd thought," lodged the heart, and the regular to and fro motion of the blood," Empedocles styled the Respiratory Rhythm.

Origens, (as was also Democritus) was familiar with the pulse, and great attention was paid to the bloodvessels, which were supposed to convey the air to different parts of the system.

For a short time now, we are to deal with the man, who boasted descent from such illustrious ancestors as Hercules and Asclepius, and who embodied the notion of practical reason against shallowness and theoretical errors—namely Hippocrates. In his book "De Mulitis Hominis," he reconstructs the foundations and builds thereon, the stable edifice of Cohn Homonal Pathology, which demands the acceptance of the doctrine of the 4 elementary juices, blood, phlegm, yellow and black bile.

We obtain most food knowledge concerning the Vascular System from the letters Hippocraticus, and these, as in other Hippocratic epistles, we find evidences of careful dissection of the limbs, and rougher examinations of other parts, having
been made. One of these pamphlets, "De Artis," gives us the relations of the Aorta and Vena Cava to the heart; another, "De Cordis," deals with the Pericardium, Septum Semicirculari Vales, and Chorda Syndonea. Arteries, Ventricle, and "Effenter" veins. Also we are told that "the seat of the understanding is placed in the left ventricle, and this is nourished by a pure and luminous fluid." In his work on Epilepsy, Hippocrates refers to the venous system, but fails to realize the different functions of veins. He imagined 1 system ran, in each leg and gave confusing accounts of the blood flow. In his mind, the Vital Spirit was inhaled from the air, filtered through the lungs, and disseminated through the body by means of arteries. She starting point of the circulatory system he, at first supposed to be the head, and later, the Aorta and Vena Cava, which opened from the spleen and liver respectively. According to Hippocrates, "De Morbo Sano," all arteries entered the heart, the left ventricle of which contained Vital Spirit which permeated all the arteries. This latter word properly primarily signified the Spleen, and Branchi, and it was not till later that it was made to represent an air (dio) carrying (tosp) vessels. The true connection between the Right and left ventricles was not recognized, but the large and superficial arteries were known generally, their ramifications and ultimate destinations being, however, erroneously described. A treatise, "De Muculis," contained a physical proof of the efficacy of the arterios of the semilunar valves in an excited heart. Proceeding, the Father of Medicine, stated that the fundamental principle of life was bodily warmth, which had its seat in the left ventricle also, and under the influence of which, the elementary fluids were formed from ingested food; blood was the chief material from which organs were built up, and it was fundamentally produced in the liver. The veins only, received the blood, which was supposed to acquire the necessary temperature in the left ventricle. Hence, propelled by the pulsating heart, it
Circulated by means of "veins" through the entire body. As far as we can judge, there was no
drier or exact account given of the contents of arteries or the left ventricle, but it was
inferred that they contained either pneuma alone, or mixed with the very smallest particles
of blood. Phenomena in confirmation of this fact were supposed to be found in the facts
that in the corpse, the left ventricle was always empty, and that a hissing sound was heard
in cases of arterial injury. An ambiguous nomenclature rapidly, meaning both "heart" and
"arteries", render vague a given Hellenistic description of the subject, but in the
"De Morbo" (ii) we find it stated that the strong muscularity of the heart prevents it
suffering from congestion of the humors.

Thus we see, that so far, no finger had been laid on the respective chord of Smith
as regards the circulation, and, although a pupil of Hippocrates, Pleadenas, made
distinctions between arteries and veins, no further knowledge was gained by the

differentiation.

In the death of the "divine Cereon", as Salvin styles Hippocrates, his sons and grandsons.
assisted them were Polybus and Hippocrates, added to a little to their inheritance of
enunciation. They imagined life to be bound up with fire which originated from the
pneuma, and was inherent in the blood, which, forcibly drawn through the members,
nourished all the body, and had as its source the heart, where all veins met. A
cooling influence on the blood was attributed to the functions of the lungs.

Now holding such tenets were styled Dogmatici, and Chrysippus of Lido, who had
been associated with the Egyptian priests, and with Italian and Sicilian scholars, had
semi-dogmatic beliefs which were in reality an agglomeration of the various dogmas
of the sects under which he had studied.

Since prominence should be given to Diocles, Ciner's "seconda etate farnese" -

after Hippocrates, who studied the vascular system after the ideas of the Sicilian School.
With him, the heart was the source of blood and from it came 2 main branches, the
propria capsa or corte and the noisy fray of venus cura, both of which gave rise to 
ruins. He believed in the pneumatic theory and imagined that the pneuma, some of which,
in addition to resting in the heart and representing the soul, also seemed to exercise a 
cooling effect and to influence sense impressions and movements. Along with the 
blood, it spread itself by veins, to the brain, and remaining parts of the body. The 
ennuiishment of the living fabric your nature was denied from the blood, but as to 
love, or virtue, no explanation was deemed necessary.

The views of the Sicilian School were very much the same as those mentioned above, 
and the pneuma was regarded as the dominant factor in organic life and the regulator 
of the same. It also furnished the heart of the body, aided satisfaction processes, and 
awoke sense impressions. The doctrine that the heart occupied a position of centrality, 
was the seat of the soul, and distributed blood and pneuma, constituted one essential 
difference between the Sicilian School, which held these views, and the Alkmaion and 
Corin schools.

About 200 B.C. the Alexandrian School was at the zenith of its power. Then, Herophilus, the 
Chalcidian, described roughly, the relationships of the vascular system, and distinguished the 
arteries conducting veins from the arteries filled with blood and pneuma, which arise from 
the heart, and passers costs six times as strong as the veins. He taught, that the 
arteries differed from all other in construction and there he named phleb 
arteries (artery-like arteries). He also discovered an important fact which has been 
rediscovered by others after him, namely that the mesenteric veins passed into the 
portal veins, and, that "vessels which come from the gut enter certain gland-like 
burrows," that is to say, he recognized the lacteals. Herophilus, also 
organized from Herophilus, and in picturesque and attractive manner he drew 
alogies between the prevalent musical theories, with their rhythm and beat, and 
the pulsation of the heart, recognizing septum, diastole and intervening pauses.
Another sophist of this period, about 350 B.C., was Aristotle, who among many other subjects, studied medicine, and expanded original views on the circulation of the blood. The following description of his notions on the subject is taken from his "De Partibus Animalium." After teaching here and there on the question of circulation, and distinguishing between the blood of different animals, he therefore drew deductions as to their mental powers and physical development, and advanced medical themes on circulation of blood. Like many of his predecessors, he imagined the heart as being the primary source of vessels, "for these arise and do not go through it," and the central heart to be hollow and full of blood. The walls also were dense, he argued, to protect the source of heat, and from the heart, the blood went to vessels, and "some flows in in the opposite direction; for without this, the heart could have no material for elaboration." The blood absorbed from the stomach, as vapour, was, he thought, converted to fluid in the bloodvessels, and was passed on as such to the heart. Bloodvessels went to the head like a narrow strait in which, the current was constantly changing to and fro. The heart received the blood both from the "Great Vessel," (the Superior and Inferior Cavae) in the Right Auricle, which was considered by Aristotle, Galen and other later men, to be an intrinsic part of the heart, and to be simply the dilated junction of the Cavae) and from the Arteria. Aristotle distinguished the liver as being the centre of the circulation, and seems to have assigned that position to the heart. In large animals he considered this latter organ to be tributary, in smaller ones, tributary, whilst the smallest creatures possessed a heart with only one compartment. The Great Vessel and the Arteria were the main blood vessels and each was the origin of other channels; each entered a different cavity, and the third cardiac chamber served as a common centre for both sides; of these three compartments, the right one had the most abundant and hottest blood, and "therefore the limbs on the right side are hotter than those on the left." The left cavity had
least blood vessel, whilst the middle one was intermediate as regards the heat and quantity of the blood, "being of poorer quality than either"; the large bloodvessels moreover were cold. Mentiiing the transverse and longitudinal grooves which mark out the surface limits of atrium and ventricle, Aristotle also made the correct embryological statement that originally the heart was unilocular but was later converted into cavities by the formation of internal septa. From the Right Ventricle, the Pulmonary Artery sprang; (this vessel was regarded as part of the Vena Cava, as on death it was joyed with blood, and as it had a similar thin wall); the smallest cavity of the heart corresponded to the left auricle, whilst the left Ventricle was the middle compartment, which gave rise to the Aorta. All these cavities were connected with the lung but only in the case of the Right Ventricle was the connection visible. The Aorta comprised all the systemic arteries and the pulmonary veins, and each side of the body had its distinct separate blood, much more impure on the right side than on the left. After treating of respiration and the mechanical processes incident on swallowing, Aristotle goes on to state that the ingested food passed to the stomach where a process of "concretion" ensued; the heat for the process being derived from the liver and spleen; the fluid part of the food then was absorbed by the bloodvessels of the mesentery, "which opened into the intestine by minute pores", and this absorbed matter in vaporous form, not yet being blood, but as imperfect serum, proceeded to the heart. This serum was denoted by the word ἐξόσμα, signifying chyle, and if we borrow a passage from the Stagirite, "De Sommo", we learn that, "in the heart and bloodvessels the ἐξόσμα undergoes a second concretion, there being the hottest parts of the body, and in the heart the serum is converted to blood, the ultimate food of all the organs. But the amount thus formed is extremely small. Blood goes from the heart by channels, arteries and veins alike, being mingled with air inhaled by the lungs which proceed..."
to the heart, — and then, is carried to all parts of the body; each organ selecting what it requires. The vessels become smaller and smaller till the tubes become too fine to admit blood; fluid no longer goes through them, though they still give passage to sweat, and especially so when the body is heated and the mouths of the small vessels are dilated. When the Great Vessel and the Aorta reach the legs, they split, and the former goes from front to rear, and the latter vice versa." As noted before, the Pulmonary Artery was regarded as part of the Vena Cava, and at its origin it lay in front of the Aorta, but on reaching the Arch, it sent its right and larger division behind the ascending part. Dilatation of the lungs was produced by heat-warmth; these respiratory structures took up air, and transmitted it to the heart for cooling purposes. When the preparation of blood by the heart was brought to ebullition, this phenomenon was manifested by pulsation.

This, in fact, completed Aristotle's knowledge of the Vascular System, and, although some of his theories and conclusions were very ingenious, and contained a few traces of correctness, his delineation was still very imperfect.

About the end of the 4th century B.C. another C tanı, Erasistratus, made observations on the cadavers of men and animals, and he brought the description of the heart, its valves, and choride tendinées to as near perfection as possible. He observed the vessels in parts, but came in considering them in the light of arteries, which at one time contained air, and, at another time, milk. He rejected the Humoral and adopted the Atomic Theory, and thought that the foundation of organic energy was the blood which was propelled exclusively through veins, allied with prænuma, "the energy carrier and dominatrix of all vital phenomena"; this prænuma was conveyed through the medium of respiration, air going by the Pulmonary Veni to the Left Ventricle. Two varieties of pneumatic substance resulted, one, the Vital Prænuma, propelled by the arteries, which governed the vegetative processes through the body; the other was Soul Prænuma, which
had the brain as its goal. Blood, Enniestates, imagined to be a conversion product of ingested food and nourishment, coming into existence first in the liver, and by the Vena Cava, being distributed by the venous system. The vascular supply of the lungs was furnished by the Pulmonary Artery, from the Right Ventricle, and valvular action acted as regulator of the circulatory mechanism. The same keen thinker and investigator, discovered the fact, that at the moment of cardiac systole, the semilunar valves opened, whilst closure of the tricuspid prevented regurgitation. A striking theory was also advanced by Enniestates thus, "Arteries, and veins stand anatomically in relationship with each other through the ultimate venous ramifications opening into the arterial terminations." This statement was significant, a diamond of truth sparkled in the bed of mistaken ideas and fallacious observations. But instead of following up this clue, Enniestates, relying on the general principles of the circulation, then en vogue, added that these sympatostomes normally remained closed, and that only in pathological conditions, and in arterio-venous anastomoses, did blood penetrate into the arterial system. Haemorrhage, he explained in this fashion, firstly prauna escaped and was followed (obeying the law of "Horror Vacui") by blood which flowed from the veins to the arteries, and escaping blood, therefore, was obtained through the connecting borders of the sympatostomes. He also declared that the blood in the "Right Heart" went to the limbs and returned again, and Vital Spirit was drawn from the lungs to the left side of the heart and was pumped back again to the arteries. It is to be much regretted that medical science was, for the time, woeful for the important speculation of Enniestates chronicled above.

Under the able guidance of Aesclepiades, the Atomic Theory was investigated in its deeper aspects. Furnishing about 1020 B.C., these workers held that atoms were united into passages (πτυχω) through which the body juices were conveyed. Pulse, the
defined as being a movement of the arteries, these alternate expansion and contraction was made visible by the entrance of pneuma. He combated the assertion that the head or the heart was the seat of the soul, with the argument that animals could live for appreciable times after these organs or appendages (the heart or head) were removed.

On Aristotle's death, the Scholastic School (namely that diseases arose from the solid parts of the body) was advanced by Helminthus and Locatio. Dissension, however, broke out amongst their followers and two sects were thereby formed, Pneumatists and Electics or Eipropathics.

Amongst the Pneumatists, Athenaeus was pre-eminent, and he held the view, as did the Sicilian School, that the soul had its seat in the heart. Respiratory motility - internal warmth and renewed the pneuma. Blood was formed in the liver by means of its inherent warmth, from the nourishing parts of food, and from the hepatic organ, was led to the heart; the arteries springing from this latter organ contained blood in addition to pneuma, just like veins, but the distinction between the two kinds of vessels consisted in the preponderance of blood in the veins, and a predominance of pneuma in the arteries.

Agathocles of Locarno, may be taken as a sample and leader of the Electic party. With his adherent, the Roman Archigenes, whose study was raised to the highest level attained by antiquity.

Passing mention might be made to Theodosius of Ephesus and Aetacius of Cappadocia, the latter whose enmity the heart with the power of drawing poison material from the stomach and other organs.

Like a refreshing oasis in a barren desert, do the elaborated and well-versed doctrines of the Grecian teacher, Salern, appeal to the mind which has been engaged in studying vague and mostly improbable theories. Born at Syracusa in 130 A.D. the great Pneumatist advocated that the pneuma...
manifests itself in a three-fold form: psychic, animal, and natural. The first named or prænuma ἡντεκον, he located in the brain, and thence it was distributed through the Nervous System. The second or prænuma Ἰονικὸς was transmitted through the heart and arteries and it manifested itself in the pulse, whilst the third, prænuma Ἀριστοκρῶν had its seat in the liver and veins. Salam recognized three stages in digestion; "firstly to the stomach where chyle is manufactured from the food; secondly chyle goes to the liver where natural spirits convert it to blood". Delving upon the third stage, Salam stated that one part of the blood traversed the liver and proceeded by special veins to the rest of the body, but another portion went through the Hepatic Vena and Ascending Vena Cava to the Right Heart where, by means of inherent warmth, further purification took place and the useless residuum escaped as smoke (αἰρετικὸς) during expiration, through the open semilunar valves. From the Right Heart the blood penetrated firstly, to the Pulmonary Artery and Lungs, and secondly through the hypotetrical diaphragm into the interventricular septum, to the Left Heart, where it again underwent a process of perfecting. This was brought about by the entrance of prænuma in inspiration to the Left Heart in diastole through the Pulmonary Veins, and mixed with the blood as prænuma Ζύγικος (Vital Spirit) and imparted to it a cleaner, thinner, and vaporous consistency. This mixture consisting mainly of the Vital Spirit, and to a less extent of blood, circulated through the body, by means of the arteries, the heart being the fountain-head of inherent warmth, the place of preparation of Vital Spirit, and the distributing organ of the latter. Salam suggested that the Right and Left Ventricles moved simultaneously, and that only the diastolic phase was active. The Right Ventricle warmed the blood in it, and dispatched it in systole through the veins. The Pulmonary Artery
supplied the lungs with blood for the purpose of nourishment only, and the left
ventricle drew pneumae during diastole, from the lungs by the Pulmonary veins,
and prepared Vital Spirit, vitalizing it with the blood mixture received from the Right
Heart, and drove the vapors compound, composed chiefly of pneumae, into the arterial
systole by its systole. The reason for the greater thickness of the wall of the left Heart, as
compared with the Right, was, that despite its airy contents, it would not be lacking
in weight, and thus destroy the equilibrium of the heart. Saltin maintained that
anastomoses occurred between arteries and veins, "between particularly the terminations
analogous with the pores in the Cardiac Septum, whereby part of the arterial pneumae
permeated the blood containing veins." He assumed a rhythmic movement of the contents
arteries and veins, but to say, as some people have not sampled to do, that he had a
knowledge of the true circulation, is simply a meaningless assertion. Saltin considered
that the heart function was mainly for preparation of Vital Spirit, and therefore was
forced to assume that heart activity only was evident after birth. This seems
investigator had unique opportunities for studying movements of the heart and great blood-
veins by observations on the heart of a boy whose stimen was removed by cauries, and
also by experimenting on animals. In opposition to Enriquetas, he showed that the
left heart contained some blood, and he had distinct views on foetal circulation, which
will be treating, in a later part of this paper. In his "On the Use of Parts of the Body",
Saltin describes the valvular orifices of the heart and the utility of the valves, mentioning
the openings in all, two for egress and two for ingress. Although the
writings of this great man show the baleful influence of premature speculation and
scientific supposition, yet, after his death in 1807, O.D., successful and fruitful
research on the subject of Circulation, seemed, for a time, to be dormant.
An African, Vincentius, contemporary and friend of St. Augustine, investigated where
the seat of the psychic functions lay. His opinion will be judged from the following
Translated passage of one of his writings: "The cerebrum is the chief part of the brain, the heart has two chambers, where the minds of both man and animals dwell, and anything of psychic nature emanates from these cavities."

And so, speculating on the causes of physiological phenomena, and discovering little worth mentioning, philosophers and anatomists of these earlier days, filled in the gaps of time.

We had turned to Churcumus, to whom we must accord a meed of praise, and here we see something interesting and tangible to consider. Amongst the theological physiologists, Clemens Alexandrinus, Gregory of Nazianzus, and his illustrious follower Gregory of Nyssa, merit special mention. The latter especially in his discussions on Natural Philosophy, introduced anatomico-physiological ideas. He thought the whole body was permeated by canals, some springing from the heart and containing pneuma (Arteries), and others (Veins) which sprung from the liver and held blood. Pneuma found its way to the lungs, whence it proceeded to the heart. The process of respiration was involuntary, and the heart, which was attached to the lungs, by its contraction, alternately drew from and compressed them, whereby inspiration and expiration resulted; the useful cardiac organ also maintained the heat of the stomach.

Dissuaders of Harvey — we shall hear more concerning them later — credit another Chrocmus, Neosios of Enesa, as having anticipated the discovery of the Circulatory System, but the theologians’ exact words will be sufficient to prove the untenability of such views. The so-called pneumatic movement of the pulse from the heart, distributing vital warmth through the arteries to all parts of the body, does so, just as the liver distributes nutrient through the agency of the veins. The expansion of the pulsating vessel draws into itself blood from the nearest vein, which seems to nourish the vital spirit; in contraction it expels all impurities through the body.
and from the invisible pores.” This, after all, is simply another fantastic view of the circulation, and deserves no place in a probable list of anticipatory facts, as regards Harvey’s discovery.

Paulus Aegina was next conspicuous amongst the 6th century authors on this subject, although his paucity of pathological and anatomical knowledge prevented him from going very far in his attempts to elucidate the knotty problems connected with the circulation, and for several centuries, medical science generally was practically at a standstill.

Without attempting to account for the intervening years, or to describe progress made in other branches of medical art, we will pass on to consider the ideas and investigations of Johannes Arzneis, a Byzantine writer who lived in the 13th century. He taught that urine was a filtrate from the blood derived from the Inferior Vena Cava, (had he substituted for the latter vein, the Malpighian corpuscles of the kidney, how near the truth he would have been!), but he did not attempt to demonstrate the physiological connection between the two. Arzneis had erroneous psychophysical principles, and he imagined that the Galenic pneuma, from the liver, from nutritive organs, was the cause of sexual power, and that the pneuma which reached the heart by the Inferior Vena Cava was then converted to Vital Spirit (Zweikov), and was then distributed through the entire body by means of arteries.

But the times were beginning to change — the pneuma was rising from its ashes — a revival of learning was setting in — men’s minds were being stimulated anew, bringing about radical changes in the scientific and literary world.

At the commencement of the 15th Century Benigo de Castri, Professor at Bologna, was pre-eminent as an anatomist, but he confused the Pulmonary Arteries and Venous, and although he had dissected over 1000 bodies, he could not understand
How the larger veins were connected with the lung. Following a short time after this man, Nicholas de Cusa (1444) bridged himself with sphygmology, and introduced the counting of the pulse, in cases of disease.

Some artists of this period, too, were eager anatomists — it was part of their education to dissect at least one body — and Leonardo da Vinci worked on 10 bodies in a vain search for a communication between the venous and arterial systems.

The year 1543 saw the printing press at Nuremberg give us Andreas Vesalius' book "Fabrica Humani Corporis," which summed the far-reaching effects of Galen's teaching, structured as the latter was by Sylvius, Vesalius' master. Thus, food was treated as going to the stomach, and alimentary canal, where it was carried to the liver, under whose influence it was converted to blood. The latter enriched by the food, was, by the same great hepatic organ endowed with the nutritive properties summed up in the expression 'natural spirits.' This crude blood was however as yet unfitted to perform the higher functions of the body. By the superior Vena Cava, it was carried from the liver to the right side of the heart and some passed by innumerable little forces in the septum to the left ventricle where, just as Galen foretold, it mixed with the inanimate air, and vital spirits were eventually produced, and the perfected blood and air were ready for their higher duties. This inanimate air also subserved the equalisation of cardiac temperature. From the right side of the heart, there was sent to the body generally, along the great veins and to the lungs along the Pulmonary Artery a fluid, followed by an eddy of crude blood, enriched with Natural Spirits only, which served the lower stages of nutrition. From the left side of the heart, there took place, there took place along the arteries to all parts of the body a fluid, followed by an eddy of blood laden with Vital Spirits, which consisted of indispensable vapors given off during the process of fermenting activity of the blood. The Vital Spirit blood on reaching the brain generated animal spirits which were carried along the nerves to bring about movements, and to carry on the higher functions.
of the body. The blood, to use Verulamius' expression "sweated" from the Right to the Left Ventricles, through microscopic passages. He accommodated his statements to the dogmas of Seneca, as he hesitated to give his own opinions, but notwithstanding his moderation in stating his opinions on this and other subjects, his book was revised by Sylvius and his contemporaries. In the first edition of his Fabrica, Verulamius hinted at his doubts regarding the Senecian doctrine, and, in the next edition, he openly expressed his dissatisfaction with the theory of interventricular fossae, and consequently brought down upon his head a storm of abuse. For his presumption in questioning the dicta of the mighty Seneca, Verulamius did good work, however, in determining the exact position of the heart in the chest, and he made a careful study of cardiac structure. He pointed out the fibrous rings at the bases of the Ventricles, and showed that the heart-wall consisted of layers of fibres connected with the fibrous rings, describing three kinds of layers; straight, oblique, and circular. From the disposition of the fibres, he reasoned as to the mechanism of relaxation and contraction of the heart, thus, contraction of the longitudinal strands drew the heart to the base, and caused the sides to bulge out, and similarly systole was occasioned by the contraction of the circular fibres. The mechanism and internal structure of the heart, Verulamius accurately described, but he had no conception either of a systemic or an Pulmonary Circulation. His work, however, when he promulgated his ideas, and avowed his doubts, ought almost to be considered the first stepping-stone to Harvey's culminating triumph.

Contemporary with, and much disliked by, Calvin the Reformer, was Michael Servetus, who in 1553 published his "Restitutio Christianismi," in which is the earliest account of the Pulmonary Circulation. In this treatise he stated that Vital Spirit was compounded of and nourished by, inhaled air and "the most subtle blood." This was the spirit, prepared by the power of heat, of acidish colour, and having in it the essence of water, air and fire. It was produced by a mixture in the lungs of breathed air and the subtle part of blood, which the Right Ventricle of the heart communicated to the Left. This communication did not take place through the septum of the heart, but the subtle blood was drawn from the Right Ventricle, by a long passage through the
De Re Anatomica, yet this work, posthumous as it was, was a branching imitation of Vesalius' Fabrica. In it, however, Columbus did correctly describe the Pulmonary Circulation, and and promulgated the theory of a biconcave heart, the right cavity ophethe containing venous blood, was larger than the left, which held vital blood, and this latter cavity was very thick, to prevent transmission, one of the heart, of its contents. Between the ventricles was an impermeated septum, for the blood is carried by the Pulmonary Artery to the lung, and, these, made thin, is brought back thence with air, by the Vein, to the left Ventricle. He, as did J. Caspar Dornmajo a Bologna before him, summed up the anatomical investigation of the period, and stated that, "anatomists hold the function of the vein-like arterv is to carry changed air to the lungs, which, fan-like, ventilate and cool the heart, and not according to Aristotlean teaching, the brain. They imagine that the lungs receive the "pulmo caprinus" (sheep lungs) discharged from the left Ventricle, and make the heart similar to a chimney." Columbus' claims to originality of opinion are baseless. Just as Halim had taught 1400 years previously, he thought that Nature had made the veins hollow, so as to pervade the whole body and carry the nutritive blood to the several members. There are reasons for believing that Columbus notions on the Pulmonary circulation were acquired either, from a work of Severus, which had excelled the pyrotechnic display made with his described and revised ophiic of the Postlitica, or by some other means not attributable to his own genius.

The year 1569 is regarded and kept holy by certain of the continental physiologists and anatomists for the same reason as we in Britain celebrate 1618 the date of Harvey's publication of his work famed "Exercitatio Anatomica." At the former date Andreas Casalpino is reputed to have discovered a physiological and continuous connection and passage of blood from arteries to veins across entwining anastomoses, but facts, adverse to his priority of claim will be discussed later. Casalpino was a naturalist, botanist and theologian, and, in his compiling medical treatise Quaestiones Prinipatiles (lib. I. Quest. iv) he discussed on the valvular action in the heart, claiming that the valves opened
when the heart dilated, and closed when contracted. The heart and lungs, therefore, he stated, 
must be dilated and contracted synchronously, or the entrance of spirits must take place when 
we excrete. It was fallacious to say that the heart and lungs were always dilated at the 
same time, for regulation of breathing was often patent, whilst it was impossible to regulate the 
rate and rhythm of the heart. When the heart contracted the arteries were dilated and vice-
versa. “Now, if the arteries were contracted and dilated at the same time as the heart, reason 
would be denied and the senses destroyed.” Casanovus therefore grasped the principle, that the 
heart at its negative, discharged its contents into the Aorta and Pulmonary Artery and, whilst 
dilated, received blood from the Vena Cava and Pulmonary Vein. In his Medical Questions, 
he seems to have been aware of the flow from arteries to veins and of the flow along the 
vains to the heart. In 1593 his famous experiments with ligatures described in Act ii, 
Quest 17, were published. “Why do ligatures remain swell on the vein and not on the near 
side of the ligature? If the movement of blood and spirits took place from the viscera to all 
parts of the body, the contrary ought to happen; when the channel was interrupted the flow 
beyond the obstruction ceased. The passages of the heart are so arranged that from the 
Superior Vena Cava, flow takes place into the Right Ventricle, whence the passage is open 
to the lung. From the lung there is another entrance into the Left Ventricle from which there 
is a way from into the Aorta, certain membranes being so placed at the mouths of the vessels 
that they prevented return. Thus there is a sort of perpetual movement from the Vena Cava 
through the heart and lungs into the Aorta.” In such words did Casanovus press upon 
his mind, and he added that when we breathe, much blood and spirits went to the 
arteries, and hence to nerves, and that while we slept some heat was carried back to the 
heart by the veins, “for natural entrance into the heart is by the Vena Cava and not by 
arteries.” Summarising, we find that Casanovus grasped the Pulmonary 
Respiration and also in part, the Systemic Circulation. He recognised that the flow of 
blood to the tissues took place by the arteries alone and that return of blood from the
...tissues, took place solely by veins. His mission was an arduous one, namely, the healing down and transplanting underfoot the old Galenic dogma, and accepted theories of the age.

Gradually advancing along the great high road of knowledge of the circulatory we now pass one of the last milestones, in the person of Hieronymus Fabricius Aemilius. He wrote on the valves, which had previously been noted and commented upon by Johannes Camerarius of Turin, and also, even prior to these, by Carvius. Fabricius gave however fuller details and showed how they were formed to delay the blood and to prevent the whole, flowing like a flood, and becoming agglomerated. He believed that veins carried crude blood, unmingled with Vital Spirits, from the heart to the tissues, and imagined them to be temporary reservoirs. In his "De Pneumaticis et euis instrumentis," he speaks of the trachea as a "rough artery," and thought that the lungs existed for the vein-like artery (Pulmonary Vein) through which air was drawn with blood to the heart. The lungs he thought, made use of three kinds of vessels, which penetrated them. Firstly, the Rough Artery, by which they drew on inspired air, which, subsequently, by the heat of the heart, was carried throughout the vein-like artery into the left Ventricle, to be converted to Vital Spirits and act as refrigerators to the heart. The lung was nourished by 3) an artery-like vein, arised like an artery, and received Spirits by a vessel having the structure of a vein.

About this period also Bartolomeo Eustachi (1560) studied the anatomy of the heart, and Julius Avanarius in 1580, discovered the Corpus Arantii in the semilunar valves, which keep his name fresh.

Also in 1540 Carlo Ruini in his Anatomy and Diseases of the Horse, taught that the left Ventricle sent blood and Vital Spirits to all parts of the body save the lungs—a modification of Galen's theory—and became another showed in close acquaintance with the functions and uses of the cardiac valves.
Van Helmont’s name might be mentioned, but although this Brussels philosopher published in 1599 the results of his investigations on the Vascular System, he merely maintained his position by his ability to harangue.

Before passing on to consider the products of ascending the 17th Century, a recollection of the former beliefs on circulation might be quite.

According to the old views, only part of the blood passed from the Right Ventricle, through the system, to the Left Ventricle, and the rest went back to the tissues. It was the former amount only that Sermius and Columbus declared to pass through the lungs. Physicians of the time of the Spanish kings that the blood was not stagnant in the body, but were had any conception of continuous stream, returning to its source, in the general system or in the lungs. If they used the word “circulated,” as did Casparius, it was used as vaguely as the “corneaux” of a French policeman. The movements of the blood were thought to be slow and irregular in direction, and the sheath was compared to the circulation in a horse.

The older anatomists also imagined that one kind of blood flowed from the liver to the Right Ventricle, thence to the lungs, to nourish them, and to the general system for the same purpose, by veins; the other kind flowed from the Left Ventricle to the lungs and general system by the arteries, which conveyed Vital Spirits. They had no conception of the function of the heart as being the motor power of the movement of the blood, doubted whether its substance was muscular, and supposed its action to be due to the exhalation of the spirits it contained. They believed that its only dynamic effect on the blood was the sucking of it in during septol, the active phase, and supposed that the chief cause of its constant movement was to ensure a thorough mixing of spirits and blood.

And now that we have progressed so far on our journey, there seems before us, the great white monument marking the achievement of Harvey, and on the inscription plate...
we read that the fundamental principles of our present-day knowledge of the Vascular System are embodied here. Born in 1578, Harvey was educated first at Cambridge, and afterwards on the continent at Padua, where he studied under Fabricius. His wonderful 72-page tract, the Exercitatio, did not see the light till 1628, and contained the foundations of his teachings and observations of 30 years. It was a condensed argument, founded on the results of dissection and careful examination. He investigated the cardiac action first fully, and found it so difficult that like Frosst, a Veronese doctor, he began to think that "the motion of the heart was only to be comprehended by God." Patient study, however, prevailed and he found out the truth about the contraction or systole and the relaxation or diastole, and that the active phase was that which drove the blood out. Causatives alone had formerly recognized this. "It is the pressure of contraction or systole which squeezes the blood into and, along the arteries, and it is the transmitted pressure which causes the pulse and the artery swells, not to suck blood into it, but because blood is driven into it by the pressure of contraction." In his experiments on a snake (Add) he describes how he saw the Vena Cava and Pulmonary Vessels on the one hand, empty and full to an inch during diastole and how the Ventricle, empty during systole into the Pulmonary Artery and the Aorta respectively. He also maintained how clamping of the Vena Cava and Aorta affected the heart, and how the primitive state that organ was returned to, when the obstacles were removed from these vessels; these facts he discovered by experimenting on a snake, which has a comparatively simple heart. In confirmation of the fact that the same blood in the body must circulate, and move in a continuous flow, back to the starting point, Harvey calculated how much blood was in the left Ventricle, and stated that part of this blood was projected into the Aorta, with every beat of the heart, representation being prevented because of the closure of the valves. He assumed that from 1/10 to 1/8 of the contents of the Ventricle escaped at every systole, that was from half an ounce to one drachm. Thus, in half an hour, 1500 - 3000 beats of the
heart would expel from 2000 to 3000 ounces, and in the same proportion, would the blood be forced into the arteries—a greater quantity of blood than was to be found in the whole body. The necessary conclusion he arrived at was that the blood of animals was driven with a kind of circular motion and was in ceaseless movement; and that this was the action or function of the heart, performed by its pulsation. At first Harvey preferred fear as to the reception of his unorthodox views by mankind at large. The idea consisted in applying the views held as to the lesser circulation, to the greater circulation. He was guided by qualitative considerations. He saw the blood from the left ventricle distributed by the action of the latter to parts of the body in much the same way as blood was sent through the lungs, and that it then passed through the veins, by invisible connecting channels, which in Harvey's case were hypothetical structures, to the vena cava and right ventricle, ultimately arriving in the left ventricle, after traversing the pulmonary vessels.

Fabrini could not see why, on pressing the veins of the forearms, the vessels gave the lie to his explanation of the functions of vessels, but Harvey, in the light of his recent knowledge, grasped the true meaning of the linseed bagpipes, showing that the valves opposed the centrifugal movement of the blood. He did not deal with the questions of natural, vital, or animal spirits, the only time when he referred to such substances, having been when he held out a vague promise for future investigation. He emphasized that the same blood passed again and again through the body, passing from arteries to veins in the tissues, and vice versa in the lungs, suffering changes in the substances and parts of the tissues, and regulating these in the passage through the lungs. In the course of his Essay, names now have been given who have been received as predecessors of the circulation, but undoubtedly the physiologist who merits most the honor of having a priority of claim forwarded and contrasted with Harvey's is Asellius.

On the 30th October 1870, Dr. Bellini Candini unveiled a monument, erected to commemorate his (Asellius') connections of Galenic errors, on the function of the liver, and to commemorate
the illadvisedness of the Engiishmwn Harvey, who in 1628 dared to arrogate to himself this mighty
truth.” Moreau in 1732 mentioned that distraction from the name of Casalpinus was made, when no
mention was made that he had known the circulation. Casalpinus did know the Pulmonary
circulation, just in the same degree as Sericetti and Columbus had knowledge of it; that was, they
credited only part of the blood from the Right Ventricle of the going through the lungs; but, Moreau
included, he demonstrated the systemic circulation by experiments and reasoning. M. de la Salle
in 1740 also had no doubt that the foundations of the Circulatory System had been established by
Casalpinus. John Rob Boyle quotes from the German, Pinckertius; “lungs draw warm blood from
the Right Ventricle through an artery, and return it by anastomosis in the lung to the Venal
Artery (Pulm.on Vain), and thence to the Left Ventricle. Air is meantime being transmitted through the
channels of the Pulmonary Vans (Branches), which are extended near the Venal Artery, not communicating
with the aperture, but tending, with a such only, the sanguinio convienitine from the Right to
the Left Ventricle of the heart, so borne out by dissection, which reveals two receptacles ending in
the Right Ventricle and two in the Left. But, of the two, one only intestine, and one like all, the
ventricle (valve) being constituted accordingly.”

Undersanding these momentous facts and impressive arguments in Casalpinius’ favour, Harvey’s name
and fame are still left untarnished. Casalpinus’ teaching at the time made little headway and scant
attention was given to his new theories. John. Hoffmann studied, as did Harvey, under Fabricius, and we
have just referred to the doctrine of the Circulation. He came after Harvey, and, if the true methods of Venal
Moments had been taught at Padua, would he not have placed the fact on record? Or is this all
in his study of the Inductive Sciences and his Harvey, as having been the discoverer of the Circulation, and
Samuel Garrette, in telling papers to the Societ, advocated Harvey’s cause and pointed out that
Harvey’s name was always connected with his doctrine by his opponents, and contemporary critics
never accused him of plagiarism. Casalpinus had very confused notions as to the veins conveying
nutritive material, and had always in his mind some unmodified idea of Vitalisties being
also carried to the tissues by the arteries. He never thought of the heart as a pulsatile organ, and
attributed dilatation, to an effusion of the spirit, whilst the collapse or contraction was due to appropriation by the heart of nutritive material. He did not seem to imagine a direct flow between arteries and veins, although he conceived some connection between them.

Vesalius, however, that discussion will never cease, as to whether Harvey really united all the conclusions and conceptions heaped upon him, in recognition of his discovery, and perhaps it is not all misplaced natural vanity, that finds anticipations of Harvey's doctrine. Petrus Paulus Syrups, a Venetian mastix, who also studied anatomy under Galenius, had an advocate in Cosciarius, who tells us that, "Syrups arrived at conclusions identical with those of Harvey, and made them known to Galenius, who did not think much of them, but related them to his pupil, Harvey, and the latter, fearing war them, elaborated and perfected Syrups' conclusions, and published them as his own. This story, however, Dr. Tophet suggests can be told in the reverse manner, wherein Harvey advanced Sundius' ideas, and in this case the Englishman gets all the credit."

Bryan in his Epistle to Dr. Charleton, pays a tribute of respect and praise to Harvey thus: "The uniting streams once thought but poured blood, whether life's pure or the body's good, from dark oblivion Harvey's name shall rise, while Sun keeps all the honour that he gave."

In Dr. Secchi, a friend of Harvey's, who edited the latter's last work, wrote a defence of the Circulation (the venae cavae theory was opposed by Hoffman of Nuremberg in 1630, by Vesalius of Padua in 1639, and by J. Riolars the younger, whilst the new and novel explanation of Harvey was accepted and admired by Roger Drake in 1637, Wener Ralephrie of Geneva in 1660, and especially by Descartes, and it quickly became popular. Riolars published his Excidium Anatomieum in which he attempted to show Harvey's theories on the Circulation, in place where he attempted to substitute a doctrine of his own. The Physiologus, however, combated his arguments and prevailed in two conclusive letters, 'The Anatomical Writings'. Riolars was unconquered, and either his orthodoxy or obstinacy caused him the mortification of seeing a "Harveian"
Illustrating some concepts were Jean Baptiste de la Peque, the discoverer of the Thoracic Duct, and the cause of the
lacteals, and also the Baptiste of Arequipa; while Pellelini too, candidly admitted Harvey's
proprietary ties. Rene Desagues, born in 1590 in his native in Montes Philosphy, spoke of
vitalizing the blood, going to the brain and finally becoming the soul which he placed in the
Pneumatic fluid, and we wonder the more at the concussions he had to make in accepting
Harvey's theory. Lacteal Convection and the Lymphatic force are closely connected with the
passage of the angiopelemo fluid and it was in 1622 that Caspar Aselli of Greven, Professor
of Anatomy at Padra, described the lacteals and the presence of valves there to prevent
backward flow; he recognized that they were channels for the removal of chyle, and
thought he could trace them to the liver. Harvey, however, hesitated to accept Aselli's
theory that all chyle found its way into the system through the lacteals. Twenty
years later, Jean Baptiste in his Experiments Nova Anatomia (1657) made known his
discovery of the Thoracic Duct and the Receptaculum Chyle (while still a student he had investigated
the latter), and also the entrance into the jugular and subclavian veins. In 1657, one
year later, Vanston published the same discovery, made independently of Scepter. This seemed to
be a special period of lymphatic and lacteal research for, before another twelve months
had added its small contribution to the vast amount of time, Claire Ruette published a
Nova Exsanguia Anatomia in which under the name of Vasa Serosa or Aquae, he described
vessels like lacteals called lymphatics which contained a clear, watery liquid. Alonzo
D'Jolins in taking his M.D. degree at Cambridge, presented in his Thesis an account of these
same lymphatics before Ruette, and some authorities claim priority for discovery for
Jolins. In the light of comparatively recent physiological research, the composition of lymph
seems to be satisfactorily explained if we suppose the liquid to be formed from the blood-
plasma, by the combined action of the physical processes of filtration, diffusion and reabsorp-
tion. The plasma diffuses through the capillary walls of the arterial capillaries, to the tissues, then, after
after reaching there, it is taken up by lymphatic capillaries, and as the pressure there is between 20 and 40 mm Hg, it is forced to pass through this pressure, the thorax where the Thoracic Duct and Right Lymphatic Duct receive the accumulated lymph, and pour their contents into Jugular and Subclavian Veins.

One great benefit of Harvey's discovery was that it rendered popular, and showed the efficacy of the experimental method of research, and rendered possible, and showing into the properties and functions of the tissues and systems, whose functions had hitherto been obscured by an impenetrable veil of signs.

Be the discoverer of the circulation who he may, Harvey, at least, took trouble and pains to publicize his views and explanations, and certainly it is, that he gave the first really complete account of the Circulatory System. It is patriotic to us, therefore, if nothing else to record the glory of discovery to him. He had the satisfaction of seeing his opinions on the circulation confirmed, by the discovery of the Capillary system, as shortly after the publication of his work the microscope was invented and made to undertake different purposes. The honour of Harvey made known to the world the mysteries of the Capillary flow, belong to Mancellia, Marcelozi of Bologna (1661) and the fact was announced in his Epistola de Pulmonibus, addressed to Bonelli. A fuller, more detailed and altogether superior description of this phenomenon was advanced by an obscure clerk at Delft, Antoni van Leeuwenhoek, who was the first to utilize the microscope for medical discovery. In a Paper to the Royal Society of London in 1688, he gave an account of the True Circulation of the Blood, and stated that the arteries and veins are connected blood-vessels. "In the arteries," he wrote, "if we clearly see that the movement of the Blood only takes place in such vessels as are so thin that only one corpuscle can be driven through at a time, we may reasonably conclude that a similar thing takes place in our own bodies." He proceeded to say that "countless (ten hundred thousand) erythrocytes (red blood corpuscles) are not so large as a grain of coarse sand.
He also saw small veins uniting to larger ones and ultimately opening into the Vena Cavae, where they went to the heart, and he also recognized arteries and veins coexisting, and running together, each sending its contents in the opposite direction. Indeed, he concluded, that he had seen the circulation of the blood to his own satisfaction, because not the slightest thing manifested itself to cause him doubt.

St. Molyneux studied the circulation in the large intestine next, in 1578, and arrived at the same satisfactory conclusions as did Heusner and de Chief.

Eold's circulation, is very different from that which holds in the normal person, and a short account of it, and the facts which led up to its discovery should have some place in this Essay.

Embryology amongst the older philosophers and medical investigators was always a favourite subject, but the ideas and notions concerning the developing organism were confused and ill-defined, until microscopic investigation was instituted. Galen, however, had clearer views, and in describing fetal circulation, he summed the statements (held by Aristotle and others before him) that the heart was the primigynous organ of the body, and he assigned that position to the liver. He gives fairly correct descriptions of the junction of the Umbilical Veins with branches from the Portal, and of the Umbilical Artery with the Spleen Arteries; also of the Foramen Ovale with its membranous valve, and gives an excellent account of the Ducti Commonii of Betstall.

The period he wrote in, being the result of pressure of the enlarged uterus upon the abdominal vessels which were in communication with the arteries of the breast. So time passed after dissertations were given and new ideas were born, but it was not until more modern investigators, aided by the microscope, took up the subject, that real progress was made, and the circulation in the Fetus, correctly described. In early embryos, villi project into the blood-vessels of the placenta and are only separated by an endothelial layer and a few extravillous cells. The circulating
The aorta consists primarily of two parallel tubes, from which Capillaries, Arterial Arches are formed, and in the completion of the last arch, medullary vessels are formed. The heart is built up by the fusion of parts of the anterior ventricular section of the primitive Aorta, and is therefore a bilateral organ. Subsequently it has a single chamber which is afterwards divided by internal septa, and during the great part of embryonic life has four cavities.

- From the Heart (right) the blood goes to the Upper limbs, Subclavian, Vena, Cava, Thymus, hence to the Right Arterial and through the aortic ventricular valve to the Right Ventricle.
- Impure Blood.

A small part of the proceeds to the lungs by the Pulmonary Artery and back by the Pulmonary veins to the Left Atrium. The greater part goes through the Pulmonary Artery to the Ductus Arteriosus (a communication between the Pulmonary Artery and the Aorta), which lies beyond the Subclavian and Head and Neck Arteries, and thus entering the Aorta is distributed to the body generally.

- From the Placenta Pure Blood to the Heart goes to the Right Atrium and through the Atrio-Ventricular valve to the Right Ventricle, hence through the aortic ventricular valve to the Left Atrium.
- Impure Blood to the Inferior Vena Cava.

The Foramen Ovale is an embryonic communication, which exists between the Right and Left Auricles. A. Buchanan, Professor of Physiology in Glasgow, some years ago, advanced theories on the condition of affairs which took place just previous to the infant's drawing its first breath. A "catalepsy of organic nature" takes place then, when the blood is drawn out of the arterial system into the expanding Pulmonary Arteries, through the Arterial Duct, and simultaneously with this blood is forced across the auricles through the Foramen Ovale, into the Pulmonary Vessels. The heart probably undergoes a momentary suspension during the process. Inflation prevents the blood being drawn through the Arterial Duct, and the whole force of the Right Auricle is required to...
send the blood through the Pulmonary Artery. Therefore, the Truncus Ossecus and Ossecus Arteriosus, their mission ended, and functions satisfactorily discharged, are obliterated and are never more called into being. The lungs, functions before birth now take the place of the placenta, and instead of oxygen being supplied to the tissues through the medium of the maternal arterial blood, the born child now oxygenates its own tissues by means of the modified air.

In addition to the broad outlines of the Circulation, it ought to be mentioned that the microscope has revealed to workers two double capillary circulations, in connection with the liver and kidney, called respectively Hepatic and Renal. The blood from the abdominal organs enters the liver by the Portal Vein, which splits up in the substance of that organ and ending in Intralobular Vessels, breaks up into a capillary network; there small channels converge to a central vein in the middle place hepatic lobule. Hence capillaries again arrive and open into Sublobular Veins, which are tributaries of the Hepatic Vein, and the blood then finds its way to the Inferior Vena Cava.

With the Renal Circulation there is a difference. The Renal Artery at the junction of the cortical and medullary parts of the kidney forms a series of arteries which give off very small branches to the Malpighian bodies, in which they break up into a capillary network. Escaping sinuous vessels from these bodies, the blood is again distributed in capillaries, which ultimately pour their contents into the Renal Vein.

Within the last 50 years great strides have been made in developing our knowledge of the Circulation. The heart has been studied and its dynamic and muscular functions fully investigated. Great discrepancies are found in the estimations of workers on the subject, with regard to the force of the heart's beat. Brodie gives it as 18,000 lbs; Langley finds it down at 80 lbs., Stephen dates at 81 lbs., James at 15 lbs., and Kiel, a Scotch physician at 590. Such striking differences are due to the different meanings the investigators attached to the term force, whether "absolute," or "usual working," "potential," effective, etc., forces.
The doctrine of Michéel was, that, the cardiac force extended no further than the ends of the arteries, and that the capillaries gave a new impulsion forwards. This view however is disproved and annulled, by an investigation of the structure of capillaries, which reveal little or no muscular or elastic tissue, being merely endothelial-lined tubes, and also by Magendie's experiment of ligaturing the Carotid Artery, and getting an immediate retardation of the blood in the Carotid Vein.

Gall was of the opinion that the blood is impelled through the extreme vessels by a force originating in the physical and chemical actions going on in the tissues of the lungs on the one hand, and of the general system on the other, but this doctrine is a pure product of imagination, as no such forces are or can were known to exist.

Haller, Carus, Barry, Magendie are names which stand out in bold relief in connection with the subject of the action of pneumatic forces (whether in the heart, chest or in both) on the circulation.

Tho. Young in the Cromwell lecture for 1808, showed that the blood-pressure diminished from the heart to periphery; that there was corresponding decrease of velocity; that resistance was greater in smaller arteries; and lastly, that the contractile cords of the arteries acted not as propulsive agents but that they assisted in regulating the distribution of the blood.

Other physiologists held that auricular of septum was of the period of one pulse to another, but more modern instruments, and delicate apparatus have proved that septum lasts the forms of a complete cardiac revolution, that is, just so longer than the time given by the older workers. It has also been shown that the total mass of blood to be moved is 8 parts of the body weight, and that the central propulsive force consists of three muscular contractions, first the great venous trunks, second, the auricles, and third, the ventricles which take place rhythmically in the named order of succession. This intermittent force imparted by the heart is transmitted and equalized by the elasticity of...
the arteries, and a uniformly active force is the result, which controls the irregular movements of the blood, and moderates the shocks which it communicates to the tissues as it
impinges them.” (Buchanan).

Possibly by his experience of the haemostatic column showed that there is an equilibrium tension through the whole arterial system, and consequently the total amount of arterial blood is contained in a single reservoir, surrounded everywhere by the same elastic membrane, and everywhere pressed upon with equal force. The force of the heart is therefore delegated to the terminal arteries, enabling them to force the blood into their corresponding veins.

The presence of valves in the Vascular system has been commented upon by physiologists, from very early times, but the true functions of these appendages were not clearly shown till Harvey's time, and we may extend the limit of complete experience and knowledge of vascular action to even a later period than the middle of the 19th Century. Summing up the uses of valves we may say that their presence in any part of the Circulatory System indicates the action of that part of a force capable of producing a retrograde movement of the
congested fluid. Lymphatic vessels possess many valves and the lymph is propelled mainly by contraction of the muscular fibres of the vessels, which (the pulsation) is assisted, in the cephalic vessels, by the presence of lymphatic hearts. In the blood vessels, valves are found mainly in the superficial veins, which are exposed to external pressure, or muscular action, whilst the absence of valves in deep-seated veins, cephalic veins and arteries, disproves the fact that the muscular fibres of the vessels are a cause of the progressive movement of the blood.

Nothing has been said so far about the special arteries of the heart. The condition of blood flow in these so-called Cormonary Arteries during the phases of the heart
beats has been the subject of much speculation and experiment, in connection with
Cardiac Physiology, Celsus in 1708 formulated his view that the filling of the
semilunar valves were thrown back during systole, shutting off the mouths of the coronary vessels, and therefore these arteries, unlike the others, were filled during diastole. In modern times Brücke has accepted this statement as part of his theory of the self-regulation of the heart beat, but experimental work of later years has formed the misconception of this theory. Mastrin, Fedoroff, and Poirier made records of pressure changes in the coronary arteries during the heart beat and found the results identical with those obtained from the aorta, and the arterial vessels; whilst Rebuffat showed a similar analogy in the ratio of velocity between the coronary vessels and other arteries. More men have shown that during systole the mouths of the coronary are in free communication with the aorta and the great pressure of contraction of the heart on the coronary system keeps it off for a time and stops the circulation through them. Each systole empties the coronary system more or less completely towards the venous side and at each diastole the distended aorta quickly fills up the empty vessel.

Methods of investigating blood pressure in the heart and arteries have been devised by such workers as Galvani, Sante, Hufeland, Helz, etc., who have invented various kinds of manometers.

In such a comprehensive essay as this, it would be tedious to give opinions on every little detail connected with the circulation, but it is at least worthy of mention that the sympathic theory, as to the origin of the beat of the heart, generally attributed to Haller (1757) is now almost universally accepted, and the neurogenic doctrine is now discarded.

One little connection between neurology and Cardiac myology is important. Till lately, 15 years ago, it had never fully been understood how contraction was transmitted from auricles to ventricles. Kent and his, almost contemporaneously discovered a delicate band of connective tissue somewhat parietal in the character of its cells, situated at the base of the auricles, and sending ramifications over the ventricles, and by this
conducting apparatus, the contractile impulse was formulated. O'Flaherty, however, deserves much praise for the discovery, as he described this "band of His and that" for all mammals, while Kent confined his explanation to a single animal. The nervous system in the heart is very complicated, and such names as Keith, Rake, Starmer, Weber, Bernard, recall to our minds nerves, stations and tracks, associated with these men. We have seen how the microscope opened up to scientific research, histological vessels, and has become more endowed in the kidney of the number of red blood corpuscles; yet, even now, while standing all our new applications and delicate apparatus, we do not understand everything about the contents of the blood-conducting vessels. Certain it is that Plasma, Red, and White Corpuscles (each particle is invested with a delicate porous membrane, permitting oxygen and diffusion) along with blood platelets, which we know next to nothing, constitute the more palpable and evident factor in Blood. The red blood corpuscles are the dominating factors in keeping the bodily frame and complexed, inside the contents envelope, are substances in solution, and also Hemoglobin, which has a great affinity for oxygen. In the lungs, this Hemoglobin is saturated with oxygen, being converted to oxyhemoglobin, and when it (the blood) returns to the tissues, the Hemoglobin gains of the oxygen. The Carbon Dioxide which has accumulated in the tissues as a waste or and product is absorbed by the Blood Plasma, all through the power of organs, and is given off in the lungs, escaping as expired air. The lungs themselves are nourished by Bronchial Arteries, which function in exactly similar ways as do the orthodex veins.

In the light of present day knowledge, then, fully oxygenated blood is pumped from the Left Ventricle, through the General System, by means of arteries, the capillaries, portal veins, complete purification of the tissues. The arterial capillaries pass on their contents, now contaminated and destitute by waste material from the tissues, to veins capillaries, which in their turn pass the blood to veins, which open into the Vena Cavae. Hence to the Right Auricle.
and through to the Right Ventricle, whence it is pumped to the lungs. There, purified once more, the "Rivulet life" returns to the Left Ventricle to commence anew, another circuit through the body.

The field of the Circulatory System has been well-explored by many illustrious hands, but still, at the present time, a few more questions require to be dug in order to make a final completion of this fascinating study.