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THE

HARVEIAN ORATION,

JUNE 25,

1875.

THE

HARVEIAN ORATION,

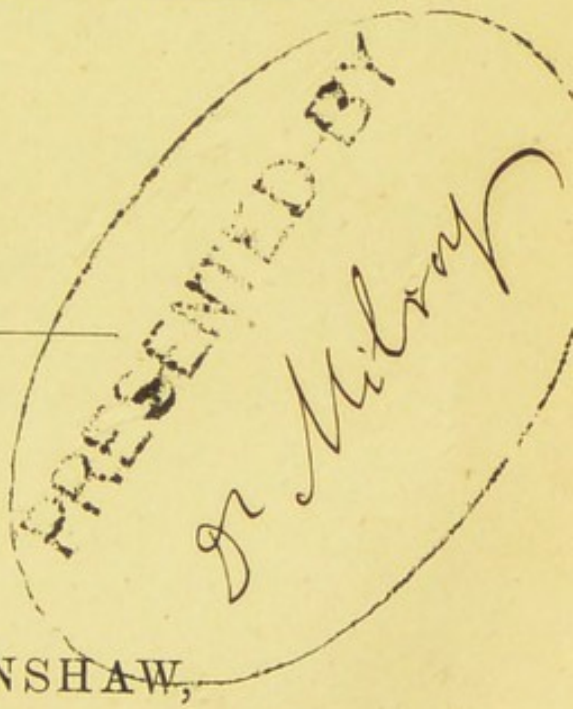
1875.

BY

WILLIAM A. GUY,

M.B., F.R.S.,

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS.



HENRY RENSHAW,

356, STRAND, LONDON.

1875.

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TO

SIR GEORGE BURROWS, BART., M.D., F.R.S., D.C.L.

PHYSICIAN IN ORDINARY TO THE QUEEN;

ETC. ETC. ETC.

PRESIDENT OF THE ROYAL COLLEGE OF PHYSICIANS OF LONDON

THIS ORATION,

GIVEN BY HIS DESIRE, AND

PUBLISHED WITH HIS APPROVAL,

Is Dedicated

WITH SINCERE RESPECT.

London, 1875.

THE HARVEIAN ORATION.

1875.

President and Fellows,

More than two centuries ago (it was some time in the month of July, 1656, nine years therefore before the great Plague, and ten before the great Fire of London), the old College of Physicians, at Amen Corner, was the scene of a most touching ceremony. In the library of the "noble building" which he had erected at his own cost, furnished, supplied with books objects of curiosity and surgical instruments, and three years previously presented to the College, William Harvey met the Fellows, his colleagues friends and pupils, for the last time. Bent beneath the weight of nearly fourscore years, worn by repeated attacks of a painful malady, "not only far stricken in years," but "afflicted with more and more indifferent health," conscious that his life must be drawing to a close

(he died in less than a year afterwards), Harvey formally resigned the chair he had held for upwards of forty years; and as the crowning act of many a deed of princely munificence, made over to the College his paternal estate.

Harvey's object in so doing was to incite other Fellows and Members of the College to like deeds of liberality, "to search and study out the secrets of nature by way of experiment," and to cultivate mutual love and affection among themselves—his means to these ends, an oration to be delivered annually within the College.

Such, in brief, is the origin of this day's ceremony; a ceremony which, for upwards of two centuries, has been the occasion of gathering together, year by year, the *élite* of the medical profession, with many a worthy representative of every department of learning and literature, art and science.

The appointment of the Harveian Orator rests, as is well known, with the President of our College. Were it not so; if I were a volunteer, self-chosen for the duty I have this day to perform, I should begin my address by words of self-depreciation; but these, under the circumstances, would be

obviously out of place. Assuming then a certain undefined and wholly undefinable degree of competence, I address myself earnestly to the task of justifying the President's choice, fulfilling your reasonable expectations, and approaching, as near as my powers permit, to my own ideal of what is due to the dignity of this College, and the memory of its brightest ornament and greatest benefactor.

The lapse of time and altered circumstances have, as you are aware, brought about deviations from the original design of the Harveian Oration. In lieu of the Latin tongue, once the written and spoken language of the learned, we now use our own native English, which promises some day to be to the whole world, what Latin was to the educated section of a small part of it; and by a sort of general understanding and consent, we meet on this occasion to do honour to Harvey himself, as the man who, above and beyond all others, has "approved" himself "a benefactor to the College," and our greatest contributor "to the sum of medical science."

In saying this, I think that I rightly represent your feelings and expectations; but on referring to the published orations of my predecessors, I find

them grouping themselves into two equal classes, the one devoted to Harvey and his labours, the other to some topic connected with modern discovery and research.

Among those who have chosen to discourse of Harvey, some (like my immediate predecessor Dr. West), have set him before us in "his habit as he lived;" others (among whom Dr. Rolleston deserves special mention, as having made an important discovery bearing on the question of Harvey's originality) have maintained Harvey's claim to be considered the real discoverer of the circulation; and one (I speak of my friend and former colleague, Dr. Arthur Farre), handling a subject of which he is an acknowledged master, showed us how Harvey, in his treatise on Generation, displayed the same ability as in that great discovery with which his name is more generally associated.

It is with this class of Harveian Orators that I elect to associate myself; and the more willingly, as certain physiological questions connected with the circulation were the first of a strictly scientific character which attracted my own attention.

Harvey entered on his work of discovery with some considerable advantages. He came of a

wealthy family, and had independent means of his own, so that he could command the very best education England or Italy could give, and either purchase, or secure through royal favour, whatever he needed for purposes of experiment and illustration. And these his easy circumstances took from him all motive and temptation to a hasty or premature announcement of his views; and though (as his writings attest) he had good opportunities of experience as physician, surgeon, and accoucheur (for in Harvey's day the three faculties were united) and turned them to excellent account, he was not overwhelmed by the cares and incessant demands of practice, and was even withdrawn more than once by command of the Court from the usual duties of his profession.

Harvey in being spared the drawbacks of poverty must have lost with them the proverbial stimulus of necessity. But happily he found, in the stirring circumstances of his times, and the example of great thinkers and discoverers (his contemporaries or immediate predecessors), that spur to exertion to which generous minds yield so ready a response. For Harvey lived in an age of excitement, political and theological, breathing an atmo-

sphere of civil strife, a witness, and a sufferer by, one of the fiercest struggles between throne and people, between power and prescription on the one side and aggressive liberty on the other, that the world has ever seen. And this state of excitement, be it recollected, was but the carrying forward of the agitation of men's minds that had arisen out of the events of the Renaissance and the Reformation.

Harvey, as I have said, had for contemporaries many great thinkers and discoverers. He might have known both Shakspeare and Milton; for he was thirty-eight years old when Shakspeare died, and thirty when Milton was born. He was well acquainted with Lord Bacon, who died when Harvey was forty-eight years of age. Lord Napier, the inventor of Logarithms, Hobbes of Malmesbury, author of the "Leviathan," Robert Boyle, Dryden, Cowley, and rare Ben Jonson were among his contemporaries. The Marquis of Worcester was busy with his water-compelling engine, and "Century of Inventions;" Sir Hugh Middleton was at work with the New River; John Woodall, author of "The Surgeon's Mate," was commending lemon-juice as preventive and cure of Scurvy; and Sydenham (thirty-three years of age

when Harvey died) was collecting materials for his immortal works, when Harvey was demonstrating the Circulation of the Blood. It is worthy of note that the "Novum Organon," and Harvey's great work, "De Motu Cordis et Sanguinis," appeared within a few years of each other. Need I add that Harvey, surviving the execution of his royal master and patron, died in the same year with Oliver Cromwell?

As to foreign contemporaries, Harvey was only by seven years the junior of Kepler, and by fourteen of Galileo, and the senior by several years both of Descartes and of Spinoza. So that Harvey was of an age to have shared that Italian journey of Milton's, during which, as Milton tells us in his *Areopagitica,* "he found and visited the famous Galileo, grown old, a prisoner to the Inquisition, for thinking in astronomy otherwise than the Franciscan and Dominican licensers thought." And here I am reminded of another advantage Harvey had in dealing with his great discovery. The views he might form and promulgate were not likely to clash with the preconceived notions of those who drew their science equally with their theology from the same source—from that Bible of which

the authorized version was first published when Harvey was thirty-three years of age; and which, laying hold of the minds of men by the sustained dignity of its language, its lofty poetry, its vivid and life-like narratives, and stirring them to their very depths by awful threats and precious promises, must have greatly added to the excitement and exaltation of the popular mind.

Harvey, then, as I have just stated, took in hand the work of discovery, with some obvious advantages. And, on the other hand, he had only to contend with the obstacles which beset all such paths as he was about to tread. He would arouse that spirit of opposition and detraction which springs up quite naturally in the minds of those who, having imbibed certain views, at the cost of much study, and from the lips of men whom they hold in respect, are asked to abandon not only the views themselves, but all that, in course of time, has grown up and clustered round them. To root up these weeds and keep them under, to select and sow the better seeds, to reap and gather in the harvest, is a work demanding both industry and patience.

Such a work Harvey took in hand when he set

himself to discover the circulation of the blood; and such industry and patience he continued to display to the end of his long life. For it should be well understood, and constantly borne in mind, that the discovery of the circulation was not a something that lay on the surface, and which any man of common discernment might pick up and appropriate. It was not like a new remedy which, having come into repute among the common people, waited only for some patient and intelligent collector of facts to affix to it the stamp of authority. It was not such a discovery as John Woodall made, when he inferred the efficacy of lemon-juice, as others since his day have done of oranges, or fruits, or vegetables, or even of a mixed diet, from the happy accident of two ships' crews, one smitten with scurvy, the other free from it, differing in the possession of the one article of diet, and in nothing else. Nor was it a mere simple and natural inference from occurrences numerous and uniform, as was the severity of the natural small-pox, and the mildness of the inoculated form of it, as all the world of Constantinople saw them, when Lady Montague made herself the organ and interpreter of a universal belief. It was not even

so simple a matter as Jenner had to deal with when he (more observant, more logical, more persevering than his neighbours and with the precedent of inoculation to help him), converted the neglected gossip of the dairy into a life-preserving principle; or (to give but one other example), the discovery of the circulation was not such a simple correction of ancient and authoritative error as Ambrose Paré made when, with a mind prepared by a wholesome scepticism, he found the soldiers wounded by gunshot, and treated by the orthodox method of boiling oil, suffering pain and inflammation, from which those he had been forced, by lack of material, to dress with a cold slimy mixture, were comparatively free.

Harvey's work was of a different order. It demanded observations and experiments of a novel kind, and a keen, penetrating, refined logic to bring it to perfection. As we think of what it was, we are forcibly reminded of the modern researches of Sir Charles Bell, and at the same time of that famous Essay on Dew, by Dr. Wells, to which logicians accord such high praise, or that other not less remarkable inquiry by which Sir George Baker, a former President of this College, com-

passed the discovery of the true cause of the colic of Devonshire.

To put the matter somewhat differently—between discoveries of a more simple and obvious kind, and that of Harvey, there is the same sort of difference as between the merit of discerning the use of a tool never seen before, and that of a man who, having the parts of a complex machine, such as a watch, a clock, or a steam-engine placed before him, should find out their uses, discover its motive force, and (being a work of human hands) succeed in putting it together, and setting it in motion.

You will observe that I take it for granted that Harvey did really discover the circulation of the blood; that neither he himself, nor his contemporaries who, whether they opposed or supported him, at least took him at his word, were mistaken about the matter. Harvey, who had come from Padua laden with university honours, bearing with him all the learning of the ancients, and the best fruits of modern teaching; intelligent, well-informed, candid, honest; doubtless spoke the simple truth when he said to the President of the Royal College of Physicians, other learned physicians, and his esteemed colleagues, concerning the great work

he dedicated to them, "*This book alone declares the blood to course and revolve by a new route;*" and equally when, in his old age, he says with allowable self-complacency, "The admirable circulation of the blood originally discovered by me, I have lived to see admitted by almost all." Harvey, fancying himself a discoverer, and all the great anatomists and physiologists of Europe sharing his belief, would be a delusion for which, with all our experience of human credulity, we are scarcely prepared!

To understand Harvey and his work aright, to appreciate thoroughly what he did, to form a just estimate of the ability with which he exposed fallacious arguments, his acuteness of observation and corresponding clearness of description, the ingenuity with which he devised experiments, and his skill in performing them, we must study not only his great work, the "Exercitatio Anatomica de Motu Cordis et Sanguinis," but also his anatomical disquisitions addressed to Riolan of Paris, and his letters to Hofmann, Slegel, Nardi, and others. Having, as in duty bound, and in accordance with the plan I had sketched out for myself, read these productions with care and atten-

tion, I venture to submit to you a brief analytical sketch of the circulation of the blood as Harvey understood it.

I may premise that nowhere, unless I am greatly mistaken, does Harvey tell us when and where (whether while a student at the University of Padua, or while studying for his degree at Cambridge, or after settling here in London) those doubts and misgivings entered his mind, without which in his case as in others, there could have been neither motive nor stimulus to inquiry. The first glimpse we get of him is when, seeking to discover the motions and uses of the heart by actual inspection of the living animal, and not from the writings of others, he stands perplexed and bewildered by the rapid alternation of dilatation and contraction, coming and going in the twinkling of an eye, like a flash of lightning; not surprised that Andreas Laurentius found these motions as perplexing as did Aristotle the flux and reflux of Euripus (that narrow sea between Bœotia and Eubœa which ebbed and flowed seven times a day or oftener) and almost tempted with Fracastorius, to think "that the motion of the heart was only to be comprehended by God." He is, as it

were, in a labyrinth from which he can only extricate himself by using greater and daily diligence, by performing frequent vivisections of a variety of animals, and by the collation of numerous observations. Having by these means discovered "both the motion and use of the heart and arteries," he proceeds to enlighten not only his friends, but the public also in his anatomical lectures, after the manner of the academy of old.

But Harvey, though he does not tell us when he first began to suspect the true state of things, lets us into the secret of the process of thought by which he attained to his grand inference. He surveys his mass of evidence drawn from vivisections, and his reflections on them, on the structure of the heart and of its ventricles, on the symmetry and size of the conduits which enter into and issue from them, on the arrangement and intimate structure of the valves, with many things besides; and then frequently and seriously revolving in his mind what might be the quantity of blood transmitted, in what time, and the like, and deeming it impossible that this quantity could be supplied by the juices of the ingested aliment, without draining the veins on the one hand, or

rupturing the arteries on the other, unless the blood should somehow find its way from the arteries into the veins, and so return to the right side of the heart, "I began," he says, "to think whether there might not be a MOTION AS IT WERE IN A CIRCLE. Now this I afterwards found to be true."

I proceed with my analysis. Harvey begins by telling us what he saw on exposing to view the heart of a living animal, especially such "colder animals" as frogs, serpents, small fishes, snails, and the like, or such warm-blooded animals as dogs and hogs, when the heart begins to flag. There is a time when the heart moves, and a time when it is motionless; and when it moves, it grows hard and tense, when it does not move, it is soft and flaccid. This difference may be both seen and felt in the heart of an eel taken out of the body; and, in all colder-blooded animals, the heart which grows pale as it moves, takes a deep red colour when it becomes quiescent; pale in the one case, because this motion is a muscular contraction which squeezes out the blood, red in the other, because the muscular walls relax, and the blood flows into the cavity. That this is so, is plain from the fact that

if the ventricle be pierced, the blood spurts out each time the heart moves, and grows tense; and, when the heart as a whole has ceased to beat, but the auricles still contract, if the finger be placed on the ventricles, each contraction is felt as a pulse, and, if the point of the heart be cut off with a pair of scissors, blood flows with each beat.

Putting together all his many observations and experiments on this division of his subject, Harvey concluded that the heart moves in two times and four places; that the auricles first contract together, then the ventricles; and that (speaking of the ventricles alone as the heart) these things happen in our bodies at the same instant: the tension of the heart, the pulse at its apex, felt striking against the ribs; the thickening of its walls; and the forcible expulsion of the blood it contains by the contraction of the ventricles.

Harvey has completely mastered the heart's motions. He knows all about them, as well as we do now; and, in discovering the truth, sweeps away these errors;—that the heart dilating, draws blood into its ventricles; that when it strikes the breast, its ventricles are distended with blood; that its fibres contract (as Vesalius thought they did)

like a bundle of twigs bulging in the centre, whereas the fibres acting together, constringe the heart and make it tense; and that (as Bauhin and Riolan asserted) it has four motions distinct in time and place—two proper to the auricles, two to the ventricles.

I must not stop to notice the multitude of curious facts by which Harvey illustrates this division of his subject; nor what use he makes of the magnifying glass to watch the heart's beat in such creatures as slugs and snails, crabs, wasps and flies, and that convenient transparent shrimp taken in the Thames and in the sea, in which the heart is seen as through a window; nor again, those observations, so minute and exact, relating to the first appearance in the embryo of the "pulsating drop of blood," and gradual development of the heart.

From the motions of the heart Harvey leads us on to those of the arteries, as seen in living animals. He tells us that at the moment the heart contracts and strikes the breast (the heart's systole), the arteries are dilated, and yield a pulse (their diastole); and that this happens with the right ventricle and pulmonary artery equally with the

left ventricle and aorta; also that the contraction of the left ventricle and the pulse in the arteries are cause and effect. If the one ceases the other stops; as the one is strong or weak, so is the other. The pulse is small and weak in aneurism, of which Harvey gives a case, for then the blood is diverted into the tumour, and so intercepted. Again, when an artery is punctured or divided, the blood is seen to spout forth with violence the instant the ventricle contracts. This is true of all arteries: of the pulmonary artery; of the vessel which leads from the heart of a fish to its gills.

Here again Harvey finds an error to correct. It was the commonly received opinion that the arteries are filled by expanding like bellows. He illustrates the true state of the case by the analogy of blowing into a glove. At the same time he takes occasion to give Aristotle his due, who says that, "the blood of all animals palpitates within their veins (meaning the arteries), and by the pulse is sent everywhere simultaneously;" that these vessels "all depend upon the heart," and move with it.

Passing now from the motions of the heart to the large vessels that enter and leave it, Harvey takes in hand the circulation through the lungs;

and finds himself freed from the doubts and difficulties which perplexed other men, by enlisting on his side that comparative anatomy, and those vivisections which they had neglected. For he tells them that they do amiss when they (as most anatomists do) limit their researches to the human body, and that when it is dead.

First then, he tells us that in fishes, which have no lungs to embarrass the inquiry, but a sac like an auricle, a single ventricle, and a vessel analogous to an artery, the blood may be seen to be driven into the vessel at each beat of the heart, and, if the vessel be divided, to issue in jets. Again, in toads, frogs, serpents, and lizards, which have lungs in a certain sense, and a voice, the blood is transferred, as in the higher animals, from veins to arteries by the action of the heart, their case being, to all intents and purposes, that of a man in whom the septum of the heart should be perforated or removed, or one ventricle made out of two—a state of things which does really exist in the embryos of those animals that have lungs, as Harvey proceeds to prove in the course of a luminous description of the fœtal heart and large vessels, both in man and in animals.

And here, again, Harvey has to correct the errors of others—of those who alleged that the large fœtal vessels which are closed after birth, when the lungs take on their proper function, exist only for the nutrition of the lungs; and of others who asserted that the heart of the embryo does not pulsate. This last assertion is plainly false; for he, and Aristotle before him, saw the reverse in the incubated egg, and in embryos just removed from the womb.

In most animals then, and in all up to the period of their birth, the blood passes from veins to arteries by the action of the heart, and it is obvious that, in creatures which have no lungs, one ventricle (the left) would suffice to distribute the blood over the body; but (and here Harvey, as is his wont, personifies Nature), when she ordained that the same blood should percolate the lungs, she saw herself compelled to add another ventricle (the right), which should force the blood from the *vena cava* through the lungs into the left ventricle. The right ventricle, therefore, may be said to be made for the sake of the lungs, and for the transmission of the blood through them, not for their nutrition: for it were unreasonable to suppose that the lungs

require more blood for this purpose, and that blood more pure and spirituous (as coming direct from the heart), than the brain, or the eye, or the heart itself.

Some there were in Harvey's day who denied that the whole mass of the blood could pass through the substance of the lungs; and to these he opposes admitted facts relating to the skin, kidneys, and liver, especially the kidneys and liver, which have so dense a texture when compared with the light spongy lungs. Drink swallowed by the gallon will pass off from the body in an hour or two, and yet it must first traverse the liver and the kidneys to reach the bladder. The liver is a special case in point, for there there is no propelling power, while in the lungs there is the force of the right ventricle and the movements of respiration to help the onward course of the blood. Columbus, then, was right when he inferred from the size and structure of the pulmonary vessels, and their constant state of repletion, that there was a passage for the blood through the lungs; and Galen might be quoted to the same purport, and especially as insisting on the function of the valves of the heart and great arteries, permitting an

onward course of the blood, but preventing all regurgitation.

Having satisfied himself respecting the lesser circulation through the lungs, and taken note also of that other circuit by which the heart itself is nourished, Harvey proceeds to the greater circulation throughout the body, and has something so novel and unheard of to say about the quantity and source of the blood which passes from the veins into the arteries, that he fears to give it expression, lest he should stir up the envy of a few, and excite the enmity of mankind at large, in whom custom has become a second nature, doctrines once sown have struck deep root, and antiquity inspired respect. Still the die is cast, and Harvey, placing his trust in his own love of truth and the candour inherent in cultivated minds, proceeds to pass in review his stores of knowledge in terms I have already quoted; and laying special stress on his subtle and profound argument, based on the obvious impossibility of the circulating system—heart, veins, and arteries—holding together, unless there were "A MOTION AS IT WERE IN A CIRCLE," indulges in a lofty flight of poetic expressions. He compares the blood forced by the left ventricle into

the arteries, and so distributed to every part of the body; then finding its way through the veins and vena cava round to the right ventricle, which, in its turn, sends it through the pulmonary artery to the lungs, to return by the pulmonary veins to the left side of the heart, to what Aristotle says of the air and rain emulating the circular motion of the superior bodies. As the vapours drawn upwards from the moist earth warmed by the sun, descend as rain to moisten the earth again, so it is with the blood. Cooled, coagulated, and rendered effete by contact with the various parts of the body, it is brought back again to its sovereign, the heart, as to its source or inmost home, there to recover its excellent and perfect state, to resume its due fluidity and natural heat (powerful, fervid, a kind of treasury of life) to be impregnated with spirits, as it were with balsam, and so sent back on the old errand of nourishing, cherishing, and quickening every part of the frame. The heart consequently is the beginning of life; the sun of the microcosm, even as the sun might be called the heart of the world; for by the virtue and pulse of the heart the blood is moved, perfected, made apt to nourish, and preserved from corruption and coagulation. It is

the household divinity which nourishes, cherishes, quickens the whole body—the foundation of life, the source of all action.

I stop for a moment to remark that, at the time Harvey wrote, nearly a century and a half was yet to elapse ere the chemical discoveries of Priestley superseded poetry by fact, and transferred to the laboratory of the lungs those life-giving changes which Harvey and his contemporaries thought they saw carried on in the workshop of the heart.

The consideration that inspired this poetic outburst of Harvey's was this—that the quantity of blood, circling through the body in some given short space of time, is far too large to be supplied by the ingesta, or used up in the process of nutrition. Harvey had gauged the left ventricle of the heart, and found it to hold upwards of two ounces of blood; and reducing his estimate of the quantity sent out at each contraction and prevented from returning by the action of the valves, to the absurdly low figure of one drachm (and all the world, he says, allows that with every systole something is projected), he calculates thus:—In half an hour, the heart beats more than 2000 times, and so sends forth in that short space of time more blood

than the whole body contains. Say that, in the sheep or dog, a single scruple of blood passes with each stroke of the heart; then, in one half-hour, about three-and-a-half pounds of blood would be injected into the aorta. This approaches the whole quantity which their bodies contain; for Harvey ascertained that in the sheep this does not amount to more than four pounds.

But if any one should object that the nutritive fluid derived from the food might quickly pass through the body in the guise of some abundant secretion, such as the milk, Harvey meets the objection by first naming the quantity of milk which an animal will yield in twenty-four hours, and then affirming that the heart by computation sends forth as much or more blood in an hour or two.

Passing over certain details relating to the quantity of blood in the body, and also to the causes which determine the frequency of the pulse, we come upon certain corroborative facts drawn from the phenomena of hæmorrhage. Divide but a small artery, and the whole blood of the body will drain away in some half-hour or less; and the same thing occurs very rapidly in amputations,

and the removal of tumours. When a butcher, again, cuts the throat of an ox, the whole mass of blood will escape in less than a quarter of an hour; and when an artery only is divided, the same thing happens, the blood spurting forth abundantly, impetuously, as if propelled by a syringe. But if the butcher did not cut the ox's throat, after he had stunned it, till the heart had ceased to beat, he could not bleed the carcass effectually.

That the arteries receive blood from the veins no otherwise than by transmission through the heart is proved by the simple experiment of tying the aorta at the base of the heart, when, if the carotid, or any other artery, be opened, it will be found empty, while the veins are full. And now we see why, after death, the veins contain so much, and the arteries so little, blood; the right ventricle so much, the left so little; facts which probably led the ancients to believe that the arteries (as their name implies) contained, during life, nothing but spirits. Harvey surmises that this is due to the fact that the action of the heart outlives the movements of respiration, so that blood is sent to the body, while none is received from the lungs.

At this point Harvey makes a direct appeal to

the evidence of the senses. He says:—If a live snake be laid open, the heart will be seen beating quietly and distinctly for more than an hour, propelling its contents, becoming pale during systole, of a deeper tint during diastole. Now seize the vein with a forceps, or pinch it between finger and thumb; and the part between the point of pressure and the heart immediately becomes empty, while the heart itself grows paler and smaller, beats more slowly, and at length seems about to die. But remove the impediment, and the heart resumes both colour and size. Now compress or tie the artery instead of the vein, and the part between the obstacle and the heart, and the heart itself become inordinately distended, take on a deep purple colour, and at length are oppressed, and even choked, with blood. But remove the obstacle, and all things at once resume their pristine state—the heart regains its colour, size, and stroke. All this "may be observed more clearly than the noon day sun;" and we have before us illustrations "of two kinds of death; extinction from deficiency, and suffocation from excess." The last of these forms of death Harvey recognised several times within two hours of death,

and before the colour had left the face, in the bodies of men who had been hanged; and he had shown to many witnesses the right auricle and lungs distended with blood, and the auricle in particular as large as a man's fist, and so full that it looked as if it would burst.

Referring to this vivisection of a snake in his second dissertation addressed to Riolan, Harvey describes the vivisection of a fallow deer, at which many of the nobility and His Most Serene Majesty the King, his master, were present. The internal jugular vein was exposed and divided; when only a few drops of blood were observed to escape from the lower orifice, while "a round torrent of blood" gushed forth from the upper orifice, coming down from the head.

And here, as lending an incidental interest to the life of Harvey, I may remind you of the many occasions on which our great anatomist and physiologist bears testimony to the personal interest the King, Queen, and Court took in his inquiries. Harvey, as is well known, was allowed to make what use he pleased of the Royal herds of deer, in his studies both of the Circulation and Generation; and he tells us how he often showed the King the

uterus of the doe in the early stages of conception, and the *punctum saliens* beating "beautifully distinct" in the sun's light; and once also to the King and Queen what he describes as "a most agreeable natural spectacle" derived from the same source. When he comes across a most curious specimen of a perfect egg within a perfect egg, he forthwith makes the King partaker of his delight. And when people tell His Serene Majesty King Charles of a certain young nobleman who, in consequence of a fracture of the ribs of the left side, had come to have a large opening there, and a sort of sac, within which, as had been supposed, the lung protruded, Harvey is sent on an errand of inspection; and having discovered that it was not the lung but the heart that had been thus strangely exposed to sight and touch, Harvey instead of taking to the King a verbal answer, takes the young man himself, "that His Majesty might with his own eyes behold this wonderful case,"—this "man alive and well" in whom he might, "without detriment to the individual, observe the movement of the heart, and with his proper hand even touch the ventricles as they contracted." Having done so, "His Most Excellent Majesty, as well as myself, ac-

knowledged that the heart was without the sense of touch; for the youth never knew when we touched his heart, except by the sight, or the sensation he had through the external integument." Thus did Royalty in the least fortunate of its representatives, and science in one of the worthiest of her sons, mutually do honour to each other; leaving behind them an example which, let us hope, will never fail to influence our Kings and Philosophers in days to come. Whatever the faults of Charles the First, neglect of science is certainly not to be numbered among them.

The circulation of the blood in parts remote from the heart Harvey demonstrates by the twofold process of describing the exact forms and positions of the valves of the veins, and making a series of simple experiments on the veins of the forearm, swollen by the ligature of the upper arm applied as in bleeding.

As to the valves of the veins, neither Silvius, their discoverer, nor succeeding anatomists, rightly understood their use. But Harvey, by careful dissection, and passing a probe either way, arrives at the conclusion that "the valves are solely made and instituted lest the blood should pass from the

greater into the lesser veins," thus favouring its motion from the lesser to the larger branches, and furnishing a conclusive argument for a circulation.

By applying a bandage above the elbow, as in bleeding from the arm, Harvey shows the site of the valves, and by the pressure of the finger, and "streaking" the blood in one direction and the other, demonstrates their action, and the movement of the blood from smaller veins to larger, always in the direction that leads to the heart. And here reverting to his favourite argument, based on figures, Harvey bids us select some length of vein, assume it to be able to hold some given quantity of blood, empty it by "streaking;" suppose this process repeated for, say a thousand times, and then judge for ourselves what quantity of blood must be always passing towards the heart, and what sure evidence its passage affords of a circulation.

We who come to the study of the circulation with minds prepared to accept the evidence of facts, and the force of arguments, can scarcely appreciate the difficulty Harvey had in convincing some of his contemporaries, whose minds were pre-occupied by certain prevailing errors. I will mention four of them.

The first consisted in imagining a passage for the blood from the right to the left ventricle of the heart through the septum ; the second in assuming an equally unreal anastomosis somewhere between the large arteries and veins ; the third that the arteries dilate after the manner of bellows, and so occasion the pulse ; and the fourth that the arteries do not contain and carry blood, but air.

Harvey meets the first of these errors by denying the state of things which they allege, as well as by statements which prove the extent and precision of his anatomical knowledge. As to communications between the two sides of the heart, he does not see them ; and as to these anastomoses, he searches for them in vain in all the principal viscera, even when he resorts to the artifice of rendering them so friable by boiling, that he could shake their tissue like dust from even the capillary filaments.

The third fallacy, which attributed the pulse to "a power communicated from the heart through the coats of the arteries, and not to the shock of the blood contained within them," thus making "the coats of the vessel the cause of the pulse," rested on the experiment of tying the artery upon a tube inserted within it—an experiment which

Vesalius and Galen prescribed, but Harvey really performed. They assumed that the part beyond the tube would not pulsate, but he finds that it does; and, by way of confirmation, adduces the case of a nobleman, his "very particular friend," whose "most attentive physician" he was. From the body of this nobleman Harvey removed part of the descending aorta, about a span long, with the two crural trunks. They had been converted into bone; and yet he had often noted the pulse in the legs and feet of this patient while he lived. Here was an experiment of Nature's own making: the bony artery was the exact counterpart of the rigid tube, and yet the facts of the case distinctly contradicted the hypothesis of which Harvey was exposing the unsoundness.

The fourth error Harvey had to combat, instead of being an unfounded assertion, is an inference based upon a fact. I will show you how Harvey refutes this fallacy, and so give you a good illustration of his method of procedure, and bring this, my analysis, to a close.

When Harvey's predecessors opened a dead body, they found the arteries nearly or quite empty, and the veins full; and accordingly they

inferred, with Erasistratus, that the arteries contained only "aerial spirits." Harvey begins his work of correction by observing that this empty state of the arterial system occurs only in that kind of death which begins in the lungs, not when the heart ceases to beat and the lungs to act at the same moment of time, as happens in more than one form of sudden death. A universal truth had therefore been assumed from a common, but still only an occasional, occurrence. And these "aerial spirits," with which the imagination had peopled the arterial system, what were they? What their consistency? Are they separate and distinct from the blood and the solids, or mingled with them? Harvey had never been able to find any of them—neither *natural spirits* in the veins, nor *vital spirits* in the arteries, nor *animal spirits* in the brain or nerves. The ancients, need I say? never found an empty space in brain, heart, or arteries, but, convinced of Nature's horror of a vacuum, they filled it with spirits. Indeed, they fancied as many spirits as there are faculties or organs. But Harvey saw in these creations of the fancy "the common subterfuge of ignorance," alleging that "persons of limited information" used

them, as indifferent poets do the gods, whenever they have a plot to unravel or a catastrophe to bring about; or as the vulgar and unlettered refer the causes of events they do not understand to the immediate interposition of the Deity. If these spirits of which people speak so confidently are of the nature of the air that issues from the breathing organs of animals, then, if an artery or vein from which blood is flowing be plunged under water or oil, the spirits will show themselves by "a succession of visible bubbles." But this does not happen with the blood, though it does with all drowning creatures without exception.

I have entered thus far into detail, at the risk of being deemed tedious, that I may create in your minds the impression which the study of Harvey's works has left upon my own, that the discovery of the circulation was a discovery in the best and fullest sense of the word. It was no mere hypothesis, suggested by analogy, and supported by a fact or two, destined some day to be cited by some learned man as an anticipation of a discovery rightly so called, but a demonstration complete and perfect up to the extreme limits of our then existing knowledge—a demonstration the more re-

markable for as much as the composition of the "fuliginous vapour" discharged from the lungs was then unknown, and the chemical necessity of a pulmonary circulation unexplained; and the magnifying-glass through which Harvey had seen the movements of the heart in the transparent shrimp taken from the Thames, had yet to be developed into the powerful compound microscope through which we now see the unbroken capillary circulation in the frog's foot.

The circulation of the blood then, was not a discovery merely, but a demonstration; and this demonstration was in part a refutation of ancient and prevalent errors, but also a revelation of new truths wrought out by as felicitous a combination of original talent, acquired learning, and unwearied industry as ever met in one man.

Fresh as I am from the study of Harvey's works, I confess myself at a loss which most to admire, his rare endowments, or the use he made of them. If his natural gifts were great, they were not greater than the resources his industry created. The objects of his study at one time shine in the clear pure light of an unclouded intellect, at another they glow with all the rich tints of a

poetic fancy. He is as ingenious in devising experiments, as skilful in performing them. He displays all the logical acumen of an Aristotle, all the industry of a Hunter. He brings to bear on his subject a large and exact knowledge of anatomy, human and comparative, healthy and morbid, and of intra-uterine life, and he makes, for the time in which he lived, an unwonted use of vivisection. And here I may remark that no thought of cruelty, no misgiving as to the lawfulness of the proceeding, ever seems to have crossed his mind.

But what has impressed me most strongly in studying Harvey's works, is the fine logical faculty which, so to speak, pervades and permeates the whole mass, and struggling for distinct and independent expression, breaks forth into clear enunciations of the principles of that philosophy which the great Italian genius Leonardo da Vinci first announced, and Harvey's contemporary, Lord Bacon, recommended to the world with all the force and eloquence of a practised advocate. Harvey, indeed, seems to have carried on together the demonstration of a great truth, and the vindication of the methods by which all truths must be explored and established. So that we have only

to search out, extract, and arrange these abstract utterances of his, in order to construct a complete system of scientific logic; just as we might, if we pleased, bring forth from one part or other of his masterpieces perfect illustrations of all the logical methods which John Stuart Mill arranges in order in his great work on logic.

That Harvey did really claim to be not a discoverer only, but also a teacher of a new logic, may be inferred from the very title of the second section of the Introduction to his work on Animal Generation:—"Of the Manner and Order of acquiring Knowledge." Indeed he tells us in express terms that, in treating on animal generation, he is anxious not merely to set forth "the sure and obvious truth," but also to exhibit "the method of investigation" which he followed, in order to "propose to the studious" "a new" and "safer way to the attainment of knowledge." And here let it be well understood, that Harvey seeks rather to revive than to overturn the method of the ancients, whose "unwearied labour and variety of experiments, and especially the industry of ancient Greece," he warmly commends. Nor does he ignore or despise the logical teachings of Aristotle; for after giving

us his own views respecting "the manner and order of acquiring knowledge" in one chapter, he presents us in another with a dissertation on "the same matters, according to Aristotle," whom "foremost of all among the ancients," he follows as his leader.

Harvey, pre-eminently a practical man; the accurate observer; ingenious in devising, skilful in performing experiments, the practised logician and acute critic of the views of others about matters which he himself studies and understands, can appreciate the great Greek philosopher whom Bacon, the man of the closet and study, industriously depreciates. This being so, what, you may ask, is it that Harvey complains of in the scientific habits and methods of his contemporaries? what does he find to reform and amend? Aristotle was in the right. Harvey in the main approves his method and his logic. How then have Harvey's contemporaries exposed themselves to rebuke and correction? Simply by lacking the industry for which he gives the ancients credit. For Harvey tells us that it was "the custom, or vice rather, of the age" he lived in, that men preferred going idly "wrong with the many" to becoming industriously "wise with the few."

Hence a method of investigating truth "erroneous and almost foolish," content with asking what others had said, instead of inquiring whether things were so or not; substituting verisimilitudes, and "knotty, and captious, and petty disputations," for truths; passing off other men's discoveries as their own; their ideas, "false fancies and empty visions," their knowledge but "a waking dream, or such a delirium as the sick fancy engenders." From this sickly state, this idleness and indolence, this lazy satisfaction with existing knowledge, this quenching of the spirit of scientific adventure, Harvey would rouse his contemporaries to exertion. He tells them how they may arrive at the "citadel of truth" by following the traces of nature, with open eyes, "through devious but most assured ways," rising from inferior to superior levels, till at length they penetrate into "the heart of her mystery." In this pursuit of truth "it is sweet," he says, "not merely to toil, but even to grow weary," for "the pains of discovering are amply compensated by the pleasures of discovery."

Harvey, then, would fain convert men from idleness to industry. But how is this industry to display itself? Not in inventing words, but in

observing things. For as there is nothing in the understanding which was not first in the sense (the well known *dictum of* Aristotle), or, as Harvey puts it, "no certain and definite idea which has not derived its origin from the senses," it is to the senses we must have recourse; first inquiring whether a "thing be or not, before asking wherefore it is," bringing all assertions "to the proof of sense," and admitting or rejecting them according to its decisions. This is the tribunal to which Harvey refers all that he has said respecting the circulation —to the "senses" not to the "reason," to "ocular inspection," not to any "process of the mind;" for "the facts cognizable by the senses wait upon no opinions," "the works of Nature bow to no antiquity, for indeed, there is nothing either more ancient or of higher authority than Nature"— Nature as Harvey is never tired of calling her, Nature "ever perfect and divine," ever in harmony with herself, never doing anything amiss or in vain, ever acting with admirable skill and foresight.

And here I am again reminded of Harvey's habit of personification—"a habit born and bred of that fine frenzy" which the Discoverer shares with the Poet, inspiring him with thoughts of the possible,

and so setting him on the track of the actual. For the philosopher, with his "scientific insight," is as truly a poet as if he wrote verses—a poet and something more. Hence we hear without surprise that Harvey, the discoverer, who is found studying mathematics, and working geometric problems within a short period of his death, finds in the pages of Virgil a perpetual spring of rapturous delight. And as the sailor personifies his ship and the engineer his locomotive, and all men everywhere the sun, moon, and stars, so Harvey puts not life only, but thought, will, power into the heart and blood. Of this his tendency to personification I have already given one example from his treatise on the circulation. I will add two others from his work on generation. Speaking of the heart, about which he has thought so often and so much, he says :—"The vesicle and pulsating point construct the rest of the body as their future dwelling-place; 'developed into the heart,' it enters and conceals itself within its habitation, which it vivifies and governs, and applying the ribs and sternum as a defence, it walls itself about. And there it abides, the household divinity, first seat of the soul, prime receptacle of the innate heat, perennial

centre of animal action; source and origin of all the faculties, only solace in adversity!" Of the blood, which Harvey saw coming into existence in the embryo before the heart itself, he says, there is "a spirit or certain force" inherent in it, superior to "the power of the elements, very conspicuously displayed in the nutrition and preservation of the several parts of the animal body; and the nature, yea, the soul in this spirit and blood, is identical with the essence of the stars." The blood is "spirit," a something "celestial," "analogous to heaven, vicarious of heaven!"

Here, and not here only, but sometimes when treating of the circulation, often when discoursing on generation, we lose sight of Harvey the discoverer, with his foot firmly planted on the earth, to see in his place Harvey the mystic, floating indistinctly in the clouds, in company with Democritus, Leucippus, and their atoms, Eudoxus and his pupil Epicurus, with their theory of pleasure as the chief good, Empedocles and Hippocrates misleading Aristotle by their doctrine of the four elements, Pythagoras and Plato, interpreters of the fantastic notions of the ancient Thebans. But Harvey is not at home in cloud-land. His fine

faculties fail him there. He is not only obscure but inconsistent, reproving in others what he allows in himself; over and over again speaking of occult forces as being of the essence of the stars, and yet objecting to other men that "they bring gods upon the scene," that they "encumber philosophy with fanciful conceits," and derive from the stars what is produced at home. Sometimes too, but, it must be confessed not often, Harvey seems to promote to the place of a personal God, whose existence, and attributes, as Creator and Preserver, he humbly recognises, some mysterious impersonal force. Harvey has also been accused of credulity in accepting the evidence of an eye-witness (an intimate friend) respecting the existence in Borneo of a race of human beings with tails; and in attributing the dispersion of certain tumours to the application of a dead man's hand. Our authority for this last statement is Robert Boyle, who says that Harvey told him he had sometimes tried this strange remedy "fruitlessly, but often with good success." It is to Boyle, too, that we are indebted for the information, derived, as he tells us, from Harvey himself, that his dissection of the valves of the veins led him to the discovery of the cir-

culation. For my part I think the account I have extracted from Harvey's works the more feasible.

Need I tell you that Harvey does not stand alone among great discoverers in thus displaying an easy belief in matters that lie beyond the sphere of their own special inquiries; or that in his case, as in theirs, to take no note of such matters would be to substitute an impossible hero for a truly great man. The portrait of the discoverer of the circulation will not be the worse for a few shadows. They will but make it the more real.

What now remains to be said of Harvey must be said in as few words as possible. Let us first weigh his great discovery in his own scales. This is what Harvey himself says of it:—"Reflecting on every part of medicine, physiology, pathology, semeiotics, therapeutics, when I see how many questions can be answered, how many doubts resolved, how much obscurity illustrated, by the truth we have declared, the light we have made to shine, I see a field of such vast extent in which I might proceed so far, and expatiate so widely, that this my tractate would not only swell into a volume, but my whole life, perchance, would not suffice for its completion;" and again, after noting

some of the leading changes in the circulation brought about by causes bodily and mental, he says:—"Such a flood of light and truth breaks in upon me here; occasion offers of explaining so many problems, of resolving so many doubts, of discovering the causes of so many slighter and more serious diseases, and for suggesting remedies for their cure, that the subject seems almost to demand a separate treatise." These were no idle words; for in his work on generation, where we should scarcely expect to meet with such statements, Harvey says, "I have occasionally, and against all expectation, completely cured enormous sarcoceles, by the simple means of dividing or tying the little artery that supplied them, and so preventing all access of nourishment . . . . to the part affected; by which it came to pass that the tumour on the verge of mortification, was afterwards easily extirpated with the knife or the searing-iron." And then Harvey gives us a case of a fatty tumour of the scrotum, larger than a man's head, and hanging as low as the knees, which he succeeded in removing without sacrificing the important organs involved in it. This case was but one of many "accomplished in opposition to vulgar opinion, and

by unusual procedures;"—a statement fully borne out by a perusal of Harvey's works. But even had it not been so, I should have given Harvey credit for being as good a judge of the originality of his methods of treatment as of the justice of his claim to have discovered the circulation. Certain it is that Harvey himself looked upon that discovery as on a very fruitful field, and that his own experience justified him in so doing. And we may take it that he either had written, or was preparing to write, several works on physiology, pathology, and therapeutics, of which the titles only are to be found scattered through his works; but which, had they seen the light, would have proved him to be no idle boaster. His treatise on the circulation would have been enlarged and supplemented by a "Physiology and particular treatise on the Blood," by "Disquisitions on the Respiration of Animals," by an Essay on "The Causes, Uses, and Organs of Respiration," and by a work on "Physiology;" and we should have had the results of his experience as a practitioner set forth in his "Medical Observations," his "Medical Observations and Pathology," and his "Medical Anatomy, or Anatomy in its application

to Medicine." Add to this evidence, if not of views committed to writing, at least of ample material collected, the preparations and writings which a puritan mob destroyed, and the books, objects of curiosity, and surgical instruments which the great fire of London consumed, to the irreparable injury of this college, and we have before us proofs of an unwearied industry guided by rare intelligence and practical tact, which it is no injustice to the greatest men who have preceded and followed him to characterize as unrivalled.

If we would judge of the spirit and temper in which Harvey worked, we must listen to the language of his old age, as he takes a mournful retrospect of his first great trouble and heavy loss. "Let gentle minds forgive me, if, recalling the irreparable injuries I have suffered, I here give vent to a sigh. This is the cause of my sorrow:—whilst in attendance on his majesty the King during our late troubles and more than civil wars, not only with the permission but by command of the Parliament, certain rapacious bands stripped not only my house of all its furniture, but what is subject of far greater regret with me, my enemies abstracted from my museum the fruits of many years of toil.

Whence it has come to pass that many observations, particularly on the generation of insects, have perished, with detriment, I venture to say, to the republic of letters." This language, so self-restrained, so gently sorrowful, reminds one irresistibly of the plaint of Priestley, who suffered a like injury at the hands of a mob, and of the touching apostrophe of Newton to the little pet that had set his papers on fire. Such has ever been the spirit of those who have done and suffered most in the service of mankind; and I may add that I have been irresistibly struck with the curious coincidence between the words of Harvey and Priestley, and in the expressions used by Harvey when he reluctantly gave over his manuscript on Generation to Sir George Ent, and by Jenner when he resisted the first efforts made to transfer him from the modest retirement of Berkeley to the busy turmoil of London life. Nor is the coincidence less complete between the will of Harvey and that of Howard, in which, after making their humble profession of faith, they prove to their friends and poor dependents that not one of them had been forgotten.

But I must hasten to a close, leaving unsaid many things which I had noted as worthy of record.

I began this lecture by presenting to you Harvey, the aged philosopher, endowing the college with his paternal estate, and providing for the annual delivery of the oration that bears his name. It is Harvey the old man whose words I shall finish by quoting, and it is Sir George Ent, on the errand that secured for us Harvey's Work on Generation, who speaks:—"I found him," he says, "Democritus like, busy with the study of natural things, his countenance cheerful, his mind serene, embracing all within its sphere." In answer to his salutation, Harvey, referring to the miserable distractions of the time, says:—"Did I not find solace in my studies, and a balm for my spirit in the memory of my observations of former years, I should feel little desire for longer life. But so it has been, that this life of obscurity, this vacation from public business, which causes tedium and disgust to so many, has proved a sovereign remedy to me." Again, in one of his letters to Nardi of Florence, in which he treats of some obscure matters connected with generation, he says: "I myself, though verging on my eightieth year, and sorely failing in bodily strength, nevertheless, feel my mind still vigorous, so that I continue to give

myself up with the greatest pleasure to studies of this kind."

To incite the fellows and members of this college "to search and study out the secrets of nature by way of experiment" was, you may remember, a duty imposed on the Harveian orator. What better course, I ask myself and you, is open to him to promote this object, than to present Harvey, the discoverer, in his old age, still finding "the greatest pleasure" in his studies, and a solace and balm to his spirit in the memory of his observations of former years; realizing to the full the truth of his own words, that the "pains of discovering are amply compensated by the pleasure of discovery."

There sits the aged philosopher, the toil and weariness of the past transformed into tranquil satisfaction, as his mind's eye rests on some spot once dark and barren, now bright and fruitful, bathed in the "flood of light and truth," which he has shed upon it; or peering into the unrevealed future, "dark with excess of light," feeling even then what we know now, that in the sense in which "a thing of beauty is a joy for ever" a truth discovered and established is an everlasting gain, conferring on generations yet to come, in the life that now is,

priceless benefits, some by direct application, some through indirect and unexpected developments.

Even in the obscure future, Harvey might have discerned thus much, that through the long stride he had taken among the many steps that lead from ignorance to perfect knowledge, minds that might have continued to be busied and puzzled with the unsettled problem of the circulation, would be set free to engage in other and more profitable inquiries; that no one could henceforth devote himself to the study of any matter relating to the physiology of the human frame, but must own himself in some degree his debtor; that every physician every time he felt a pulse, would have a more intelligent appreciation of its indications, every surgeon who should stanch a hæmorrhage, or tie an artery, or perform an operation, would do it with a firmer hand, in consequence of his discovery of the circulation.

And these annual orations!—may we not venture to hope that in as far as, year by year, they faithfully portray Harvey, in his studious youth, busy manhood, and serene old age; they promote the objects he had in view, supplying with motive, example, and encouragement, all who are now

striving to render the life that now is, longer, healthier, pleasanter, happier, by manifold methods of cure, palliation, and prevention; in full assurance that true knowledge is real power; and that, if we make the discovery of truth our motive, and use intelligent industry as our means, we shall not miss some portion of that rich reward which fell in unwonted measure to the lot of him whose "immortal memory" we honour this day, for this among other reasons, that he conferred upon us, in the full practical sense of the words, the Discovery of the Circulation of the Blood.

POSTSCRIPT.

It will be seen that, throughout my Harveian Oration, as now published, I have abstained from the use of notes; for I was anxious to present to the reader a continuous, unbroken text. But it is the more necessary that I should acknowledge the obligations I have incurred to the elegant and scholarly translation of the Works of Harvey made for the Sydenham Society by Dr. Robert Willis. It is his English version that I quote throughout.

For facts and dates relating to the Life of Harvey, I am indebted partly to the same source, and partly to the "Roll of the Royal College of Physicians" compiled by our learned librarian, Dr. Munk.

What I have said on the subject of Harvey's belief in the efficacy of the hand of a corpse, and on the origin of the inquiries which led to his discovery of the circulation of the blood, will be found borne

out by reference to "The Works of the Honourable Robert Boyle," published in six volumes quarto in 1772. The passages to which I have referred occur in vol. ii. p. 167 and vol. v. p. 427.

This handsome and complete edition of the Works of the Christian Philosopher will be found in the Library of the College.

THE END.