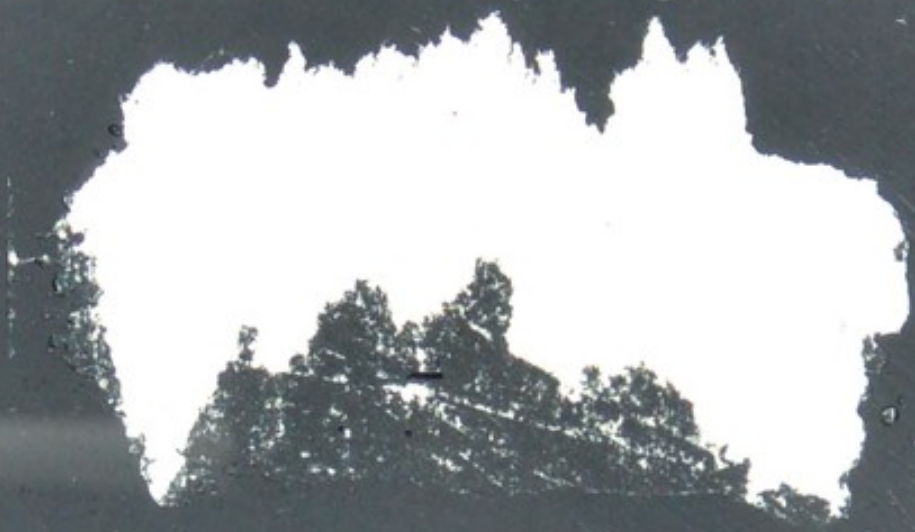
The advancement of science by experimental research : the Harveian oration, delivered at the Royal College of Physicians, June 27th, 1883 / by S.O. Habershon.

THE HARVEIAN ORATION

JUNE 27. 1883.

S. O. HABERSHON



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LONDON
PRINTED BY ODELL AND IVES, 18, PRINCES STREET,
CAVENDISH SQUARE, W.

THE ADVANCEMENT OF SCIENCE

BY

EXPERIMENTAL RESEARCH.

THE

HARVEIAN ORATION,

DELIVERED AT

THE ROYAL COLLEGE OF PHYSICIANS,

JUNE 27TH, 1883.

BY

S. O. HABERSHON, M.D.,

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LONDON :
J. & A. CHURCHILL,
11, NEW BURLINGTON STREET,

(2)

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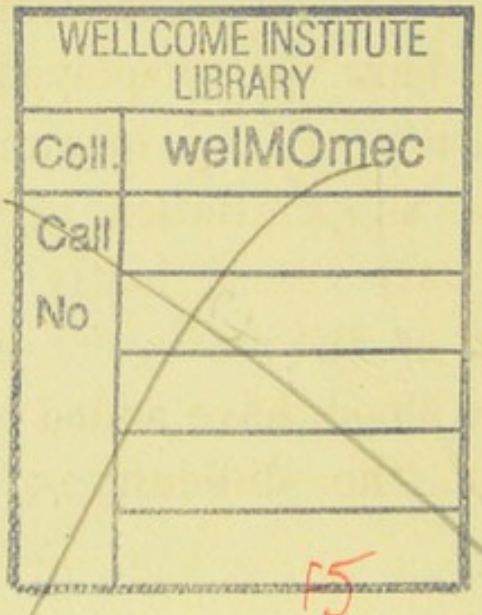

THE HARVEIAN ORATION,

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MR. PRESIDENT, AND FELLOWS OF THE COLLEGE OF PHYSICIANS:—When I received from the President the request that I would, during the present year deliver the Oration which is associated with the name of the illustrious Harvey, I felt great distrust in my own capabilities of rightly performing the duty allotted to me; and that feeling has become more intense as the work has gradually opened before me. The eloquent words that fell from previous orators, the learning and research that have been displayed, the talented vindication of the memory of Harvey, and the substantiation of those claims, which have most justly been awarded to him, as the discoverer of the circulation of the blood, have added to my consciousness of the difficulty of my

task, and have rendered it almost impossible to find new subject matter to place before you. I must ask your indulgence, whilst I seek to fulfil the object of Harvey in establishing this Annual Oration, namely, to commemorate those who have shewn themselves benefactors to the College, and to exhort the members to search out and study the secrets of nature by way of experiment.

Harvey was a lover of scientific truth, and he sought to advance science by observation and by direct experiment. Like others who had preceded, and still more those who have followed in the same pursuit, the mind not only became absorbed but enraptured in the work, and as any fragment of truth was unfolded, the desire to discover more became intensified. The eye was not satisfied by seeing, the intellectual thirst could not be quenched nor the hunger assuaged; and such is always the character of true scientific research. There is a dignity in science, and the mind that seeks to find out its mysteries is ennobled in the search;

it expands with the effort, even although one branch of science alone is studied, and one line of thought is pursued. There is a reward even in the mental exercise, for it gives intellectual strength and constant pleasurable excitement. Each truth really gained is a stand point for further advance: an Alpine traveller experiences intense satisfaction when the summit of his mountain climb is attained, when after hours of labour, and, it may be of danger and fatigue, he feels that his object is reached, not to speak of the wonderful beauties then unfolded before him; but, his delight is not to be compared with the joy of the philosopher when the discovery of some new fact in science has rewarded his toil, and a higher stand-point of truth has been arrived at.

Like the very mountains themselves truth is stable; not as the vague hypothesis which too often surrounds it like dense vapour or fog, truth is unchangeable, even as is its author. The works of God reveal Himself, for He is the author

of that which science searches out.

"Thou art in all things great, not small in any,
"Thine even praise shall never rise nor fall;
"Thou art in all things one, in each thing many,
"For thou art infinite in one and all."

Every object in nature bears the impress of the Divine hand, and the book of nature reveals His wisdom, his beneficence, his creative power and his superintending providence. I have no sympathy with those who, whilst they seek to open the book of nature, would close the more precious volume of Divine revelation: both emanate from the same source, and when rightly understood will never contradict each other. The scriptures were not intended to teach science, but they never contradict it, however they may seem to be opposed to the false teaching of imperfect investigation. The unfolding of scientific truth is truly an evolution; it is a gradual process like the expansion of the beautiful leaf-bud; wonderfully wrapped together, but spread open under the silent powers of light and heat and growth; so is truth gradually revealed under the sunlight of advanced science. It would be unwise to

guess the form and the delineations of the expanded leaf or flower from the mere outline of the bud, and guesses in science too often mislead and hinder the advance of truth. *Direct experiments* have led to the establishment of scientific facts, but mere *reasoning* on hypothetical data has been the greatest hindrance to the progress of science. The history of physiological science illustrates these statements, and in no branch of physiology is it more remarkable than in that of the circulation. In the discovery of the circulation of the blood the process was a gradual one; the steps were often uncertain, and too frequently were retrograde in character. The story of the great discovery of Harvey has been often told, and my predecessors have traced it out step by step with accuracy and with skill. I do not wish to go over the same ground, for it has been better done than I could possibly expect to be able to do it.

Fragments of truth as to the function of the heart, and the nature of the circulation are found in the writings of Plato,

of Aristotle and of Hippocrates; and the term that Plato gave to the large vessel—the aorta, is still retained by us; but the knowledge was very confused. The lungs were regarded as an apparatus to cool the heated blood, and to reduce the natural warmth, both emanating from the heart as their source; it was believed that the arteries contained spirit, and that the veins distributed the nourishment collected from the stomach and intestines to the rest of the body. Aristotle declared, that the pulsation of the heart arose from its sudden inflation from new material supplied by the food for fresh formation of the blood. It is difficult for us so to divest ourselves of facts now established and to realize the state of medical knowledge in those early times.

But let us turn to another great physician, one who was almost regarded as divine in his unfoldings of the truth of medical science. I refer to *Galen*, he was born in the year 131 A.D., when the Roman empire had become aroused by the power of Christianity. Galen lived

in a time of persecution; although he was regarded by some as an enemy to Christianity, I cannot conceive of a pagan giving utterance to the sentiments which Galen wrote, and he was evidently acquainted with the writings of the Old Testament. Galen, though the friend of the Emperors, Hadrian and Marcus Antoninus held views which were inconsistent with pagan worship; he says, that "true piety is not shewn in the sacrifice of hecatombs of bulls or in causing clouds of fragrant incense, but in studying myself to know, and in making known to others the wisdom, the power, and the goodness of the Creator."* It would be well if many

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*In writing on the use of parts in the animal body he seems to be struck with its beauty, and says, "Ego Conditoris nostri verum hymnum compono; existimoque, in hoe veram esse pietatem, non si taurorum hecatombas ei plurimas sacrificaverim, et casias aliaque sexcenta odoramenta ac unguenta suffumigaverim; sed si noverim ipse primus, deinde et aliis exposuerim quænam sit ipsius sapientia, quæ virtus, quæ bonitas."

Galen de usû partium Lib III.

men of high attainment of our own day could copy such an example. Galen held correctly that the heart, though unlike other muscles was still muscular in its action; he knew the structure of the valves of the heart, but he affirmed that there were pores in the septum between the ventricles which allowed some of the blood to pass from the right to the left side of the heart. Here he asserted what *reason* fancied rather than what he learnt by *direct* observation—a lesson to us, even at the present day, of the danger of forming our opinions on hypotheses rather than on established facts. Reason affirms that such and such things are true, but further observation subsequently disproves them. How slow we are to learn this lesson, but how disastrous has been the result, when the statements of reason are received as facts, and are regarded as solid bases upon which scientific truths may be built; for like buildings upon unstable foundations they crumble and decay when really tested. It is a slow process to get rid of these

phantoms; the authority of great names, and the attraction of beautiful theories nicely accommodated and smoothly glossed over, give these emanations of thought the semblance of truth; and those who will not receive them are regarded as far behind in that which constitutes mental vigour and attainment. The vague notions of Galen had immense power and held the minds of men in bondage for nearly 1,200 years; and, it was only when direct observations were made and dissections were carefully studied by Vesalius and Servetus, that those shackles upon thought were unloosed. Galen regarded one ventricle of the heart as connected with nutrition and nourishment; the other, the left, had to do with vital spirit; he believed, that the blood sent to the lung was especially for the nourishment of the lung itself, though he was quite ignorant of the circulation of the blood through the lungs. Vague notions of transfusions and interchange of blood and air between the arteries and veins were held, but nothing like the true

circulation of the blood was dreamt of; the blood was said to flow backward and forward, the vessels having different offices; and instead of the blood being propelled by the contraction of the muscular structure of the heart, the expansion of the heart, the diastole, was regarded as the most important movement and it was attributed to an imaginary innate heat. How different from the simple truth brought to light by the immortal Harvey! When direct experiment was made by Galen, truth was elicited, and one link was formed in the chain of facts connected with the circulation; he shewed, that when an artery was ligatured and afterwards opened, blood was poured out, proving the nature of its contents to be blood and not spirit; and, he also ascertained by experiment that bleeding from the arteries emptied the veins. These observations led to results of a very different character from his deductions from reason; one careful observation as to the nature of the ventricular septum would have disproved his hypothesis of perfor-

ations through which blood could mix between the two sides of the heart. The experiment led to the truth, the reasoning without fact led to error. The fallacies engendered by the fertile imagination of a learned philosopher were only dispelled by the direct observations of those who followed, and especially by the untiring labours of Harvey. The opponents of research by experiment on living animals would have left us in the darkness and ignorance of Galenic times, for the dawn of light and scientific truth were due to experiment and not to mere reasoning.

Vesalius, in 1512, rebelled against the assertions of the older fathers in physic, and he set at nought the mere authority of Galen. He first shewed, that the blood passed through the vessels of the lungs from the right to the left side of the heart, and that the blood was modified in its transit. Servetus, about the same time published the same truth of a pulmonary circulation, but he still held, that the venous blood derived from the liver was for nourishment, and that the blood in

the arteries was spirituous and adapted for the heat and vital endowment of the body. The former great anatomist, Vesalius, nearly lost his life from the Inquisition, but Philip II., having interposed, he was compelled, in order to escape a cruel death, to make a penance journey to Jerusalem, and having been shipwrecked on his homeward journey, died at Zante or Crete; the latter philosopher or enthusiast, Servetus, was in 1553, burnt at the stake by those from whom more charitable measures might have been expected, whatever wild errors and false doctrines were entertained.

Other anatomists followed, and prepared the way for the fuller investigations of Harvey,—Columbus Realdus, Eustachius, Faloppius, and Arantius. Fabricius of Aquapendente, was professor of Anatomy at Padua, when Harvey was a student there in 1598. Fabricius had no correct idea of the circulation, although he rediscovered the valves in the veins; Cœsalpinus, born in 1519, had been professor at Rome; he died in 1603, and a remarkable circum-

stance connected with his history is, that his countrymen have, after his death, attempted to prove that he knew more than he ever dreamt of during his life; he knew the pulmonary circulation, but adhered to the doctrines of Galen, and believed that the blood had a to and fro motion in the vessels; it is considered by those who have given him the honor to which he was never entitled, that Cœsalpinus knew the circulation, because he found that when a ligature was applied the veins swelled beyond it; but he explained the phenomenon by stating that the blood sought to return to the heart in its wonted direction.

My predecessor, Dr. Johnson has, I believe, fully shewn that the claims of Cœsalpinus are without adequate foundation; and, whilst we would give all the credit that is due to the talents and researches of Cœsalpinus, we cannot find any warrant for the statements that Harvey obtained from him the knowledge of the circulation. The truths that had been ascertained were the result of direct experiment and exact

research; the vague hypotheses that had been handed down from century to century had been the result of reasoning on insufficient data.

The times of *Harvey* were among the most eventful of English history; the liberty of religious thought was being felt and exercised its influence; the demand for civil and religious freedom was coexistent with scientific research, with literary advancement, and with extension of commerce. It is surprising, that the tumultuous years of civil strife did not check the ardour of the student of nature. Harvey was born at Folkestone in 1578, during the closing years of Elizabeth's reign; and, it is probable, that when a boy of 10, he saw from the cliffs of his home something of the Spanish Armada, which was intended to stop the freedom of thought and of spiritual life in our favoured land. The facts of Harvey's life are well known, how at 16 years of age he went to Caius College, Cambridge, took his bachelor's degree in medicine, and then spent four years at Padua, where

all that was known in Anatomical science was taught, and where the germs of his future discoveries were probably formed. In 1602 he graduated in medicine, and soon after came to London and began the active duties of his professional life, but we have very slight records of these years. In 1604 he joined the Royal College of Physicians and became fellow of the College in 1607. Two years later we find, that he obtained the office of Physician to St. Bartholomew's Hospital, and had received Royal support in his application. In 1615, Harvey was appointed lecturer on Anatomy and Surgery at the College, but it was not till 1628, that his great work was published, his "Anatomical disquisition on the motion of the heart and blood vessels in animals." James I. had died three years before in 1625; Shakspeare had finished his career, and Sir Walter Raleigh had been unrighteously led to the block when the eventful times of Charles I. were ushered in. Harvey was a lover of peace, and a student of science, but, he could not have remained un-

moved by the political events that were passing before him. In the same year that his great work was published, 1628, was the petition of Rights, in 1629 Sir John Eliot was condemned to the Tower, and the King began that system of defiance to the Parliament which led to the civil war, and to his death. Harvey had been appointed one of the Physicians extraordinary to James I., but it was not until Charles had been on the throne for five or six years that Harvey was appointed physician in ordinary to the King.

Harvey was then in the height of his professional career ; his discoveries were becoming generally known, and he had established the great truths connected with the action of the heart, and the course of the circulation. For hundreds of years it had been supposed that the diastole of the heart, its expansion, was the most important movement, but Harvey *saw* the heart contract, and proved that the contraction, the systole of the heart, was that which was preeminently the propelling power, forcing the blood into the lungs and into the

arteries, whose walls more dense than the veins yielded to the pressure. If he had been content to reason only, he could never have shewn the error of the Galenic doctrine. It was by experiments on living animals that the truth was made clear to the mind of Harvey. Let us quote his words, and I use the translation of Willis, published for the Sydenham Society. "In the first place then, when the chest of a living animal is laid open and the capsule that immediately surrounds the heart is slit up or removed, the organ is seen now to move, now to be at rest; there is a time when it moves, and a time when it is motionless." "These things are more obvious in the colder animals, such as toads, frogs, serpents, small fishes, crabs, shrimps, snails, and shell fish. They also become more distinct in warm blooded animals, such as the dog and hog, if they be attentively noticed, when the heart begins to flag, to move more slowly, and, as it were to die; the movements then become slower and rarer, the pauses longer, by which it is made more easy to perceive

and unravel what the motions really are, and how they are performed."

Again he writes, "the very opposite of the opinions commonly received appears to be true; inasmuch as it is generally believed that when the heart strikes the breast and the pulse is felt without, the heart is dilated in its ventricles and is filled with blood; but, the contrary of this is the fact, and the heart when it contracts is emptied. Whence the motion which is generally regarded as the diastole of the heart is in truth its systole; and in like manner the intrinsic motion is not the diastole but the systole; neither is it in the diastole that the heart grows firm and tense, but in the systole, for then only, when tense, is it moved and made vigorous."

One quotation further from the works of Harvey; he writes, "What remains to be said upon the quantity and source of the blood which thus passes, is of so novel and unheard of a character, that I not only fear injury to myself from the envy of a few, but I tremble lest I

have mankind at large for my enemies, so much doth wont and custom that become as another nature, and doctrine once sown and that hath struck deep root, and respect for antiquity influence all men. Still the die is cast, and my trust is in the love of truth, and the candour that inheres in cultivated minds. And sooth to say, when I surveyed my mass of evidence, whether derived from vivisections and my various reflections on them, or from the ventricles of the heart and the vessels that enter into and issue from them, the symmetry and size of these conduits;—for nature doing nothing in vain, would never have given them so large a relative size without a purpose—or from the arrangement and intimate structure of the valves in particular, and of the other parts of the heart in general, with many things beside, I frequently seriously bethought me, and long revolved in my mind, what might be the quantity of blood which was transmitted, in how short a time its passage might be effected, and the like; and not finding it possible that this could

be supplied by the juices of the ingested aliment, without the veins on the one hand becoming drained and the arteries on the other getting ruptured through the excessive charge of blood, unless the blood should somehow find its way from the arteries into the veins, and so return to the other side of the heart, I began to think whether there might not be a *motion as it were in a circle*. Now this I afterwards found to be true; and I finally saw that the blood, forced by the action of the left ventricle into the arteries, was distributed to the body at large, and its several parts, in the same manner that it is sent through the lungs, impelled by the right ventricle into the pulmonary artery, and that then it passed through the veins and along the vena cava, and so round to the left ventricle. Which motion we may be allowed to call circular." Thus Harvey made known to the world the discovery which has been of the greatest value in physiological science: it has revealed many things in the pathology of disease which could not otherwise have been understood, and has

conferred the greatest benefit on the human race.

Never was the value of experimental research more clearly demonstrated. The links in the chain of truth on this all important physiological question had been obtained by experiment, Harvey united those links to which he had made such important additions, and proved beyond doubt the circulation of the blood. He shewed how the blood passed in a continuous stream, and although the valves of the veins had been previously described by several older anatomists, as by Sylvius, Eustachius, and especially by Fabricius of Aquapendente, Harvey explained their true value and demonstrated their action. His work absorbed his mind and his energies, even whilst in his strange duties on the field of battle at Edge Hill, in October 1642; whilst in charge of the young Prince and of the Duke of York he was engaged in reading, till warned by cannon shot that he was in dangerous proximity to the scene of carnage.

Soon afterwards in the same year we hear

of him at Oxford, with Dr. George Bathurst, watching the development of the chick, more congenial to his peace loving soul than war and bloodshed. The victories of Cromwell and the Parliamentary armies at Marston Moor, and at Naseby indicated the waning fortunes of the King, and after 1646, Harvey, who had attained to 68 years of age ceased to follow the King to whom he seemed to have been greatly attached, and he went to reside with his brother. His interest in science did not cease; the same industry in the study of physiology was characteristic of his later as well as of his earlier years, and in 1651, his work on generation was published; it was imperfect in many respects, but it was an indication of the character of the great philosopher. His manuscript medical observations had been destroyed in the earlier part of the Civil war by a senseless mob, and he never ceased to deplore the loss he sustained.

Harvey retained his mental faculties till an advanced age and died in 1657, aged 80 years; a year before one who had

taken the most active part in the civil contest of the time and had placed himself on the pinnacle of power,—I refer to Oliver Cromwell. The views of Harvey were regarded as extravagant, and truly they might well be so esteemed, for they were in direct opposition to many views that had been regarded as established truths. It had been supposed that the blood flowed from the larger veins into the smaller; Harvey proved that the reverse was the case, and that the blood reaching the smaller vessels from the arteries returned from smaller venous branches to the larger trunks till the heart was reached. He did not know of the true anastomoses of the vessels; that remained for Malpighi, who was born in the year that Harvey's work was published, and who in 1661 saw the capillary circulation in the frog. What Harvey had attained was gained by direct observation, wherein he failed, was in leaving this safe path for one of hypothesis; but it is pleasant to regard him as a man of earnest religious thought; and Cowley writes,

"Thus Harvey sought for truth in Truth's own book,
Creation; which by God Himself was writ."

Harvey believed in the immediate agency and fully recognised the personal character of God and His superintending power. True science has not been advanced by the effort to set aside this great fact which runs through the whole of Divine revelation.

I delight to read from Willis's translation of Harvey's works the following words of truth from a student of nature:—"We acknowledge God, the supreme and omnipotent Creator to be present in the production of all animals, and to point as it were with a finger to his existence in his works, the parents being in every case but as instruments in his hands. In the generation of the pullet from the egg, all things are indeed contrived and ordered with singular providence, divine wisdom and most admirable and incomprehensible skill. And to none can these attributes be referred save to the Almighty first cause of all things, by whatever name this has been designated; the divine mind by

Aristotle, the soul of the Universe by Plato, the Natura Naturans by others, Saturn and Jove by the ancient Greeks and Romans; by ourselves, and as is seeming in these days, The Creator and Father of all that is in Heaven, or earth, on whom animals depend for their being, and at whose will and pleasure all things are and were engendered." (On Generation, p. 462.)

Such was the immortal Harvey; a mind endowed with the highest gifts. The attainment of the knowledge of the circulation was a gradual evolution of the truth, as one portion after another was observed, till the whole was clearly seen in the beauty of its simplicity; it was the reward of patient research, and often by experiment on the living animal. I cannot find a better answer to those who in their mistaken kindness of heart to lower animals would perpetuate ignorance, than by reference to the inestimable benefit of the researches of Harvey. To stop the advance of science is to encourage the darkness of ignorance. If the laws of the

present day had existed in the time of Harvey, we might have remained for long years ignorant of the action of the heart and of the circulation; and the knowledge of disease and the best curative measures would have remained unknown; or Harvey might have returned to Padua to make his experiments. If it were possible, it might be well for those who raise such a vehement outcry against the means often best fitted for physiological research, namely, experiment on living animals, if they ceased to partake of the advantages which humanity has received from these researches.

Time would fail me to describe the advances made in physiological science since the time of Harvey. The lacteal vessels were discovered by Aselli, and more fully by Pecquet of Dieppe, who described the mesenteric vessels, traced them to the receptaculum chili and onward to the thoracic duct. It was a hundred years after Harvey's work that Stephen Hales used a manometer to estimate the pressure of the blood, and afterwards Poiseuille introduced

a mercurial one. More recently, Volkman and Ludwig, have advanced our knowledge of the subject, but, perhaps the most interesting investigations of later times in connection with the circulation have been those of Claude Bernard, who has shewn that section of the cervical sympathetic on one side of the neck was followed by a rise in the temperature and by dilatation of the blood vessels on the same side; on these experiments followed the discovery of the inhibitory action of the pneumogastric nerve on the heart itself.

Leaving these facts connected with the circulation, let us turn for a few moments to one of the most ardent students of nature of recent times, most patient in observation, diligent in research, an investigator of those minute circumstances which are often the guide to clearer truth, a profound philosopher on whom this college delighted to confer the highest honour as a physiologist. I refer to *Darwin*; his facts are wonderful and entrancing, his deductions are *not* proven. What is more pleasant than to study his observations on plants

and on animals? and perhaps none of his works are more attractive than his investigations on earth worms; in which he shews, that animals hitherto regarded as of but little interest and service in the economy of nature are of the greatest value and designed to be of incalculable benefit to man. Darwin proves that animals undergo changes greater or less in degree from modifying circumstances, and in this way that varieties are formed, and wonderfully adapted to the circumstances in which they are placed; that these variations are transmitted to the offspring; that many changes in plants and in animals can be produced at the will of man by altering the conditions of life; that some varieties are more permanent than others, and the surroundings of particular animals or plants may be so altered, that they fail to comply with the necessities of life and the animals or plants then cease to exist. There may indeed be a struggle for existence, and a survival of those which can live under existing conditions; but, all these modifications do not *prove* that animals in their

varied forms and characters are derived from a few forms, or from mere living protoplasm *without* divine interposition or even that species are thus produced. Some of the lower forms of life, the infusoria and rhizopoda have existed unchanged for enormous periods of time, whilst others have by some means or other attained to wonderful instinct and to marvellous adaptations to life. How full of interest are the minute changes in ants! their peculiar habits, their sterile members, their slave holding propensities! there are alterations in different varieties, but they are ants still, and they shew throughout, we think the wonderful design of a superior mind, the mind of God. The instinctive skill of the bee may lead to the construction of the perfect cells of the hive bee, and the less perfect one of the humble bee, but they are bees still; and, it is difficult to believe, that by tracing backward, however remotely to primitive germs we should find the ant and the bee produced from a similar origin, without divine interference, although belonging to the same division of

the animal kingdom. To what but direct design could we trace the electric organs of the torpedo and electric eel; or the remarkable arrangement for the fertilisation of orchids. The manifold peculiarities of animals and their adaptations, require, we think, more than *mere* natural selection and the forces of the living structures of the animals themselves to produce structural changes; the exquisite beauty of the eye in the different classes of animals according to their conditions of life is, we consider, due to the direct power of a beneficent Creator, and so with every other sense, and the instincts of every species; the tribes of insect-life and their wonderful habits, the adaptations of birds and animals to their food requirements and mode of life, the carnivorous to its need and the herbivorous to its wants, the migratory birds and the aquatic diver, each indicate more than mere progressive development by insensible steps.

According to some theories, the swallow would at first, we presume, be satisfied with short journeys, but the next and succeeding

generations would take more extended flight to warmer climes. The poison bag of the cobra or of the rattle snake would according to the same theory by slow degrees attain its deadly venom, but whence the first beginning ?

The difficulty of the non-propagation of hybrid species has not been fully overcome in these reasonings ; neither do we witness the interminable variations of species which would exist, if the theory of self-progressive formation were correct.

Whilst allowing all the facts that Darwin discloses, let us keep to the facts themselves, and not be led into hypotheses which are not proven. Science has been advanced by facts observed and proved, but where deductions are brought forward and received as truth, when the basis is only hypothetical, science has not been helped, neither by Galen nor by Harvey, nor by any student of nature. The wonderful and beautiful truths elucidated in embryology do not prove the statements of evolutionists, but rather shew that a higher power controls the development.

Darwin says, "I believe that animals are descended from at most four or five progenitors and plants from an equal or lesser number" (Origin of Species); but is number anything with the Creator, or does He descend to our standard?

The development of higher animals is a gradual process and by successive stages; but, the presence of branchial fissures in the embryonic neck does not necessarily shew, that the animal is at that stage a fish; neither does the imperfect septum in the heart of the mammal during embryonic life show, that at that time it was a reptile. These gradations are doubtless the steps by which the end can be best attained; just as in the formation of a sheet of glass, the workman takes a portion of molten glass, but he does not roll it into a plate as one might suppose; on the contrary, he blows it into a sphere; then by gentle pressure, whilst he rotates the globe of glass, he moulds it into that which is well known as a glass shade; then, whilst still revolving, he cuts off the upper part and leaves a cylinder of glass;

at last, by dividing the cylinder longitudinally, and placing it in the furnace it gradually unfolds and becomes a plane surface. The process is that best adapted to carry out the design of the workman, and so in higher development and with a nobler artificer.

It is difficult to understand, that in the Australian continent the marsupial animals, similar in character to those which existed before the chalk in geological periods, should *not* have continued to evolve new species, if the laws referred to had been simply in operation; in other countries, the most diverse forms of animal life are recognised, because, we think, new species were there introduced by direct interposition.

There is constant change on every hand, gradual development in every part of the natural kingdom, one variety by almost imperceptible steps is linked on to another, and withal the hand of God is seen in every gradation. Just as in the unfolding of His character and purpose towards man; at first only by type and shadow, until we

see the full unveiling of Himself in the incarnation of his own Son; ever and anon by fresh *direct* manifestation adding to that already given; so in nature, we have indications that there has been direct interference with the chain of events; often gradual, sometimes changes of overwhelming force, but all carrying out the scheme of infinite wisdom.

Whilst speaking of the changes in animals, I would advert to those of even greater interest in man. On him more than on any other form of animal life has the influence of modifying circumstances been manifested in altering his character, in raising or lowering his mental endowments and even in changing his physical structure. Slowly have these changes been brought about, and at our own day they are seen to be in operation. The climate in which man resides wonderfully reacts upon his physical state; the heat of the torrid zone demands that the system should become accustomed to it; the requirements for the maintenance of animal heat are altered, the normal functions are easily

disturbed, the activity of the cutaneous transpiration is necessarily increased, the mind during the intensity of the heat often becomes less able to perform its function, and unless by degrees the system becomes acclimatized the health utterly fails and the life may be forfeited. The Hindoo and the Negro have become accustomed by many generations of life to a state that the European cannot bear; the organism is changed, and the alteration is not only represented by the pigmental colouring of the skin, but by an adaptation in the whole economy. An opposite state is observed amongst those whose lot is cast in the colder regions near the Arctic Circle; the Greenlander and the Esquimaux, by many years of change through succeeding gen. erations can bear with impunity and with enjoyment a temperature which would soon be fatal to the inhabitants of Central Africa. The food requirements of man are different, and whilst the Hindoo can live and thrive on rice, the Icelander needs his more oleaginous sustenance, the oil and the blubber become his life supply; and every

intermediate condition is found in the varied countries and localities of the world. An insufficient supply of nourishment soon tells not only upon the growth and nutrition of the body, but upon the energy and power of the mind. The poor half-starved peasant in the Connemara bog and desolate land deteriorates not only in his physical organism, but in that which is man's proudest endowment, his faculties of thought and his power of reason. The struggle to obtain a meagre existence drags the man down to a lower level, and the same painful fact is demonstrated among the tribes of Africa, the degraded inhabitants of Terra del Fuego, or the famine-stricken inhabitants of India or China. The condition of man may change in a descending scale instead of advancing to the civilization of more privileged races. The circumstances of social life add other modifying conditions to man in his national existence. Compare the lithe athletic Indian with the phlegmatic Turk, the Bedouin Arab in his wild nomadic life with the quiet cultivator of the soil; the

hardy fisherman and sailor exposed to the vicissitudes of weather and to the storm and tempest, with the man whose life is spent in one close room or for long hours in a poisoned atmosphere. The life is changed, and the consequences are seen in succeeding generations, till the whole race is affected, and the impress is witnessed in the most marked divergence of character, thought and action.

But there is another evolution in man. Morbific changes take place from the result of modifying conditions; an evolution which is the direct result of pathological states. The parent may be affected with syphilis, and the offspring becomes altered in its whole development and growth, and if beside one or both parents have a strumous or scrofulous diathesis, or have shewn a proneness to cancerous disease, the state of the offspring is modified still further; or with a tendency to gout another force is presented, and the resultant is an altered phase of life. Still further, the parent may have a nervous system that is extremely sensitive and easily disturbed; it may be

that there have been epileptic attacks or a tendency to mental affection and insanity; a superadded source of disturbance is given and the resultant of combined forces is manifested. All these causes of change may be yet more diverted from healthy action by the circumstances in which life is placed; not only as regards good food, pure air and the surroundings of civilized life and education, as contrasted with the wretched state induced by poverty and starvation, imperfect clothing, dark and offensive dwellings, *but* to these may be added an aguish locality, producing miasmatic disease, and having a baneful influence upon the whole being. The clinical observer witnesses the result of these combined morbific forces in a hundred forms, and they produce results which are most embarassing unless understood.

Almost every advance in science has been made by the direct questioning of nature, whether we go to Lavoisier and trace the wonderful steps in chemical science, or from Bichat we note the progress in Biology. It has been by experimental researches

and especially on living animals that the important discoveries on the nervous system have been fully established; but very little was known of the difference between the motor and sensory fibres of the spinal cord before the observations of Sir Charles Bell; the truths that he made out were due to experiment, for when he rested on mere reasoning his deductions failed; but the facts he did establish have wonderfully assisted in the right understanding of disease, and they have been of the greatest value. I need not refer to Marshall Hall, to Duchenne, to Brown Sequard, Hughlings Jackson, and to many others; but the more recent investigations of Dr. Ferrier, also connected with the nervous system, and the localization of cerebral function have been and will be of increasing value in rendering the knowledge of disease more accurate and in leading to correct diagnosis and treatment.

An illustration of the value of study of the kind just mentioned is well shewn in the pathological investigations connected with tubercle. The subject is one replete

with interest, and especially in connection with a disease of so frequent occurrence as phthisis. The phenomena of tubercle since the time of Laennec and Carswell, have been wonderfully cleared up. There was truth in the views of Dr. Williams, who referred tubercle "to a degraded condition of the nutritive material," and that in its origin it differs" not in kind, but in degree of vitality and capacity of organisation. The clinical observations of Dr. Addison rested on a sound basis, when he declared that inflammatory changes were of the greatest importance in the pathology of the disease. The microscopical observations of Gulliver have been advanced by W. Addison, Virchow, Langhans, Rindfleisch and many others; but perhaps the most interesting observations have been those of Villemin.

He shews, that animals inoculated with fresh tubercle become tuberculous; tubercles were found in the spleen, in the lungs and in other viscera; from his experiments it was supposed that there was a special virus which would reproduce the

same morbid change when introduced into the system. If these experiments had been made twenty years later the original statements might have gone forth as established truths; but science was then less trammelled. Burdon Sanderson, Wilson Fox and others tested the theories that had been broached. It was found that although the experiments were true, that tubercle could be artificially produced, it did not require tubercle to be used, that other animal substances, that vegetable irritants, and still more that a mere wound would suffice under certain conditions. That these irritants when placed within the tissue became surrounded by product of a cheesy and inflammatory character, and that the subsequent changes in these products in a diathesis of a tubercular type led to secondary deposit of an advanced character in connection with the lymphathic system. It is true that some guinea pigs were used to establish these most interesting and important pathological truths; mere reasoning would have misled, the advance of science was due to *direct exper-*

iment, and happily the barriers were not then existing and the obstacles to research had not been devised. With all these observers from the commencement the unfolding of medical science has been a gradual one, as step by step the darkness of ignorance was dispersed by increasing knowledge.

It is the object of science to attain to exactness in knowledge, and the advance of one line of truth reacts upon others in close relation with it ; during later years how much has been ascertained as to the character of the blood itself, its more precise composition in varied periods and states of health, not only as to its white corpuscles and the red corpuscles, and perhaps other forms, but as to the migratory character of the leucocytes ; chemical science has unfolded much and will do still more, but the microscope and the spectroscope have added immensely to our knowledge in relation to the pathological, as well as the physiological changes of the blood itself. With a better knowledge of the heart and its valves, and

the altered states of its muscular fibre, we have learnt not only the true nature of the sounds of the heart, but the import of their morbid changes; the sphygmograph and cardiograph have led to as much accuracy in clinical observation, as the use of the thermometer has done in the study of febrile conditions. The discoveries in the physiology of the brain and the whole nervous system have explained the facts of pathological science; but it has been a gradual evolution of truth. In no branch of medical science have greater advances been made, than in the knowledge of the diseases of the spinal cord and of the whole nervous system.

During the last few years a comparatively unexplored field of research has been laid open, which is now being pushed forward with determined zeal, the study of the morbid germs and their connection with the etiology of disease. The bacteria are now regarded as the actual or the proximate causes of many maladies; they are the simplest forms of vegetable life, and are classified according to their

several characters. To the presence of some of these forms of the Micro-cocci are attributed many terrible varieties of disease, as pyæmia, erysipelas, internal suppurations. Some of these bacteria are found in the blood; they undergo stages of development and decay, and induce secondary changes in the tissues with which they come into contact.

Pasteur in his observations on splenic fever in animals and the manner in which the bacilli may be modified by successive germinations in proper fluids, has unfolded facts which will probably prove of immense value, but the interest has been eclipsed by the observations of Koch in reference to the bacilli of phthisis. That these bacilli are found in the expectoration of true phthisis has been established, and their presence has also been observed in the tubercle in the lung itself; while it is stated very positively that they do not exist in other forms of pulmonary disease as chronic pneumonia and chronic bronchitis; that in consequence phthisis is a disease directly communicable from one

person to another. Whilst there is much to warrant this opinion let us bear in mind that it is not as yet established; fuller facts will doubtless be brought forth by other observers, and it is wiser to wait for clearer knowledge before we at once accept the opinions of these observers upon the data already made out. We desire to know more of the natural history of these bacilli, whether they are really animal structures possessing individual life and advancing to fuller development, or mere fragments of living organism about to pass into inorganic forms. They increase in size, spores appear to be produced and set free, or they propagate by simple division. But whence do these bacilli come to be found in the cells of tubercle, and not to leave traces behind them of their mode of entrance, or are these the commencement of degenerative change in ill developed tissue?

The munificent grant of the Grocers' Company in the city of London, for the establishment of a Quadrennial Discovery prize, may, we trust, lead to advancement

in the knowledge of these organisms which are placed at the very threshold of animal life, but capable it would seem of stopping the course of life itself in the highest forms of development.

It would be premature to say that the morbific germs of ague and of fever have been fully recognized, but it would be an incalculable boon if the germs of such diseases as cholera, of scarlet fever, of small pox could be so made out, that we might be led to measures which would mitigate their severity, render them harmless, and stop the ravages which they produce. In reference to the last named, small pox, if one fact more than another in medical science seems to be established it is, that by vaccination *properly* performed the system becomes so fortified against variola that the severity of the disease is mitigated, and that it is frequently rendered almost harmless in its attack or entirely warded off.

It may be quite correct that, in some cases after vaccination from syphilitic subjects the system may become contami-

nated, but such instances are still doubtful, and they are of very rare occurrence; and, we believe, that with proper care they would never have happened. So also the disturbance from the vaccine inflammation may be followed by eczema or impetigo, or glandular enlargements; but these troubles would probabiy have arisen in cachectic children, even if vaccination had not been performed.

The science of pathology is advancing with rapid strides, but the fear is lest by hasty generalization, its progress be retarded, and that hypotheses imperfectly established be used as the solid bases upon which to build explanations of disease and modes of treatment. The safeguard against these disastrous results lies in the plan adopted by Harvey in the study of the circulation of the blood, *patient research, direct experiment and exact observation.* Every one interested in the advancement of medical science must, we think, desire that those hindrances which have been formed by mistaken sentimentalism may be laid aside, and that true knowledge

may be promoted in all its beneficent purposes. The advancement of science is the pride of a nation and a benefit to the whole human race.

The science of medicine is unselfish in its character, the members of its profession give their knowledge for the general good, and the influence is spread for the service of man wherever he may be found. The advances made in Germany, in France, in the United States, and elsewhere, are soon known and reflected back with the additions obtained by our own investigators. The International Medical Congress two years ago was an illustration of the commonwealth of science, and of the brotherhood of medical men. Medical science like a stream flows on quietly and noiselessly as regards the external world. Its source is far back in ages that are gone by, but it diffuses on the right hand, and on the left a thousand benefits to those who avail themselves of it. It derives strength and power from other sciences as they join in, as streams flowing on in like direction, and thus the power for good is enhanced.

The surface of the stream may be ruffled by stones or by mud thrown in, but these sink to the bottom and are soon forgotten. Those who have derived benefit, and it may be almost life itself from medical skill, often cast aspersions when the need has ceased—they foul the spring that has refreshed them. According to the published accounts we have no record of a campaign where the wounded suffered less from blood poisoning and sloughing sores than in the recent war in Egypt. Sir W. McCormac states:—"During this campaign there was never any outbreak of those infective diseases that have hitherto decimated the wounded in time of war. There was no pyæmia, no erysipelas, and no hospital gangrene as the result of wounds. Not a single man lost his eyesight, though there were 1494 cases of inflammatory diseases of the eyes admitted to hospital;" but, the doctors were expected to take the onus of the failure of other parts of service, to secure pure and wholesome bread, supplies of beds and sheets, pure water, and to contend with the plague of Egyptian flies;

they have, however, the consciousness of having rightly performed their duty, and when the facts are fully known we believe they will be honoured.

It has been the common experience of medical men that oftentimes when the praise was most deserved they have received the least; and it may require years and even a life time to shew the true value of work and to remove the mistakes of insufficient knowledge and of prejudice. It was so in the great work of Harvey himself; some of the practitioners of his own time thought lightly of his views and of his practice, for they did not understand the importance of his discovery. The mountain peak may shine brightly in the morning sun light, but a deep shade may be cast from the mountain side till a brighter light and noonday sun dissipate the shade; in like manner some great truth may stand forth in all its brightness, but a dark shadow may be cast beyond, till ignorance is lost in the sun-light of completer knowledge.

The pages of nature lie open before us

all; and, the lessons we have sought to establish from the works of Galen, from Harvey, and from Darwin are, that we must seek to unfold the mysteries of science by patient research and experiment, and, that we must not accept as truth any theory which is the result of our own reasoning unless it can be proved by observation. To every humble minded investigator there is an ample reward, and the fault is not in nature, if we do not enrich ourselves from the stores laid before us.

"Accuse not nature; she has done her part
"Do thou but thine; and be not diffident
"Of wisdom; she deserts thee not, if thou
"Dismiss not her, when most thou needest her nigh."