THE HARVEIAN ORATION
ON
MODERN DEVELOPMENTS OF HARVEY'S WORK.

Delivered at the Royal College of Physicians.

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[AFTER some introductory remarks, and a touching reference to the death of Sir Andrew Clark, the Orator proceeded]:

But while we are saddened to-day by the death of our late President, we are gladdened by the presence amongst us again of one whom we all reverence, not only as a former President of this College, but as one of the great leaders of clinical medicine in this century, Sir William Jenner. Like Harvey, Sir William Jenner is honoured by his College, by his country, by his Sovereign, and by the world at large. In times of trial and danger the lives of the Royal children were committed to the keeping of Harvey by his King, and to-day the care not only of her own life, but of that of her nearest and dearest is committed to Sir William Jenner by his Sovereign, in the full and well grounded assurance that in no other hands could they be more safe. The great clinician, Stokes, wished to have as his epitaph: "He fed fevers;" but Jenner has advanced much beyond Stokes, and, by showing us how to feed the different kinds of fevers, has saved thousands of valuable lives. To-day this College is acknowledging his right to rank with Sydenham, Heberden, Bright, and Garrod, by bestowing upon him the Moxon medal for clinical research. In numbering Sir William amongst its medallists the College honours itself as well as him, and in acknowledging the great services he has rendered, it is on this occasion acting as the mouthpiece of the medical profession not only in this country but in the world at large.

I purpose to consider to-day some of the modern developments of Harvey's work, more especially in relation to the treatment of diseases of the heart and circulation. There is, I think, a certain advantage in this also, inasmuch as one is apt by considering Harvey's work only as he left it, to overlook the enormous extent to which it now influences our thoughts and actions, and thus to comprehend its value very imperfectly. As he himself says:

> From a small seed springs a mighty tree; from the minute gemmule or apex of the acorn how wide does the gnarled oak at length extend his arms, how loftily does he lift his branches to the sky, how deeply do his roots strike down into the ground![1]

How very minute is the gemmule from which has sprung everything that is definite in medical science, for this gemmule is no other than the idea which Harvey records in these simple words: "I began to think whether there might not be motion, as it were, in a circle."

Out of this idea has grown all our knowledge of the processes of human life in health and disease, of the signs and symptoms which indicate disease, of the mode of action of the drugs and appliances which we use, and the proper means of employing them in the cure of disease. In the works that have come down to us we find that Harvey developed his idea physiologically in several directions. He discussed its application to the absorption and distribution of nourishment through the body, the mixing of blood from various parts, the maintenance and distribution of animal heat, and excretion through the kidneys. How far he developed it in the direction of pathology and therapeutics we do not know, as the results of his labours on these subjects have unfortunately been lost to us by the destruction of his manuscripts during the Civil War.

We are proud to reckon Harvey as an Englishman by birth, but he is far too great to belong exclusively to any country; men of various nations, and scattered all over the face of the earth, acknowledge him as their teacher, and have played, or are playing, a part in developing his discovery in its various branches of physiology, pathology, pharmacology, semeiology, and therapeutics. Americans, Austrians, Danes, Dutchmen, French, Germans, Italians, Norwegians, Russians, and Swedes have all shared in the work, and so numerous are they that it would be impossible for me to name them all. Stephen Hales, however, deserves special mention, for he was the first to measure the pressure of blood in the arteries, and the resistance offered to the circulation of the blood by the capillaries was investigated by Thomas Young, a Fellow of this College, who ranks with Harvey, Newton, and Darwin as one of the greatest scientific men that England has ever produced.

Harvey's desire that those who had done good work should not be forgotten was founded upon his knowledge of mankind, and of the tendency there is to forget what has already been done by those who have gone before us. The opposite condition often prevails, and the past is glorified at the expense of the present. But sometimes the present is wrongly glorified at the expense of the past, and past work or past benefits are forgotten.

THE SOUNDS OF THE HEART.

Good examples of this are afforded by physiological views regarding the action of the vena cava and pulmonary veins and the causation of the cardiac sounds. Harvey appears to have thought that the vena cava and pulmonary veins were simply dilated passively by the passage of blood into them; but the fact that they possess a power of independent pulsation was known to Haller[2], and was brought prominently forward by Senac[3], who regards the vena cava as the starting point of the whole circulation. He says:

> The vena cava is therefore the first motor cause which dilates the cavities of the heart; it fills the auricles and extends their walls in every direction.

These observations appear to have been almost forgotten until they were again made independently a few years ago[4], and in one of the latest and most accurate physiological treatises which now exist, the description of the cardiac cycle is nearly the same as that given by Senac:

> A complete beat of the whole heart, or cardiac cycle, may be observed to take place as follows:—The great veins, inferior and superior venæ cavæ and pulmonary veins are seen, while full of blood, to contract in the neighbourhood of the heart; the contraction runs in a peristaltic wave toward the auricles, increasing in intensity as it goes.[5]

The pulsation of these veins, however, cannot be a constant phenomenon, or it would have been noticed by such a keen observer as Harvey.

The sounds of the heart were discovered by Harvey, or at least were known to him, for he speaks of the sound caused in the œsophagus of the horse by drinking, and says:

> In the same way it is with each motion of the heart, when there is a delivery of blood from the veins to the arteries that a pulse takes place and can be heard within the chest.

This observation remained, so far as we know, without any further development until the time of Laennec, who introduced the practice of auscultation; but it was a Fellow of this College, Dr. Wollaston,[6] who first discovered that the muscles during contraction give out a sound, and although many observations were made regarding cardiac murmurs by Corrigan, Bouillaud, and Piorry, it was chiefly by a Committee of Fellows of this College—Dr. Clendinning, Dr. C. J. B. Williams, and Dr. Todd—that the question was finally settled, and the conclusions at which they arrived are those now accepted as correct.[7] Yet in recent discussions regarding the origin of cardiac sounds little mention has been made of the work of this Committee, and indeed I first learned of the value of the work from a German source, Wagner's *Handwörterbuch der Physiologie*.

THE CIRCULATION AND THE ACTION OF DRUGS.

The importance of these observations in the diagnosis of heart disease it would be hard to overestimate. But diagnosis alone is not the aim of the physician, whose objects must be to prevent, to cure, or to control disease. A knowledge of physiology may greatly help us to prevent disease, not only of the heart and vessels, but of every member of the body. The control and cure of disease may also be effected by diet,

[1] *The Works of W. Harvey*, Sydenham Society's Edition, p. 320.

[2] *Elementa Physiologiæ*, 1757, Tom. 1, pp. 410 and 399.
[3] *De la Structure du Cœur*, Livre IV, ch. iii, p. 24.
[4] *Proc. Roy. Soc.*, 1876, No. 172.
[5] M. Foster, *Textbook of Physiology*, 6th edition, Part I, ch. iv, p. 231.
[6] Wollaston. *Phil. Trans.*, 1810, p. 2.
[7] Report of Committee, consisting of C. J. B. Williams, R. B. Todd, and John Clendinning, *Brit. Ass. Rep. for 1836*, p. 155.

and regimen, but it is undoubtedly in many cases greatly assisted by the use of drugs, and is sometimes impossible without them. Harvey knew that drugs applied externally are absorbed and act on the body, so that colocynth thus applied will purge, and cantharides will excite the urine;[8] but the action of drugs when injected into the blood appears to have been tried first by Christopher Wren, better known as the architect of St. Paul's than as a pharmacologist. Bishop Spratt says:

He was the first Author of the Noble Anatomical Experiment of injecting liquors into the Veins of Animals; An Experiment now vulgarly known; but long since exhibited to the Meetings at Oxford, and thence carried by some Germans, and published abroad. By this Operation divers Creatures were immediately purg'd, vomited, intoxicated, kill'd, or reviv'd, according to the quality of the Liquor injected. Hence arose many new Experiments, and chiefly that of Transfusing Blood, which the Society has prosecuted in sundry Instances, that will probably end in extraordinary success.[9]

The method originated by Wren of injecting drugs into the circulation was skilfully utilised by Magendie for the purpose of localising the particular part of the body upon which the drugs exerted their action, and he thus conclusively proved that the symptoms produced by strychnine were due to its effect on the spinal cord. His experiments showed that the rate of absorption from various parts of the body varied enormously, and, through the teaching of Christison, led to the introduction into practice by Dr. Alexander Wood of that most useful aid to modern therapeutics—the hypodermic syringe.

The first quantitative experiments on the effect of drugs upon the circulation were made, to the best of my knowledge, by James Blake, in 1844, in the laboratory of University College, at the suggestion of the late Professor Sharpey, with the hæmodynamometer of Poiseuille, which had then been recently introduced. [After a graceful reference to the vast knowledge and utter unselfishness of Professor Sharpey, and to his great influence in physiological progress in this country through the work of his pupils, Burdon Sanderson and Michael Foster, under the auspices of Acland and Humphry, the Orator proceeded]: Yet more than to anyone else since the time of Harvey do we owe our present knowledge of the circulation to Carl Ludwig He it is who first enabled the pressure of blood in the arteries to record its own variations automatically, so that alterations could be noticed and measured which were too rapid or too slight to be detected by the eye. To him, also, we owe the plan of artificial circulation by which the changes in the functions of the organs and in the vessels which supply them can be observed, quite apart from the heart, lungs, or from the nervous system.

Like Sharpey, Ludwig is a great teacher, and like the great architects of the Middle Ages, who built the wonderful cathedrals which all admire, and whose builders' name no man knows, Ludwig has been content to sink his own name in his anxiety for the progress of his work and in his desire to aid his pupils. The researches which have appeared under these pupils' names have been in many instances, I believe in most, not only suggested by Ludwig, but carried out experimentally with his own hands, and the paper which recorded the results finally written by himself.

The Mechanism of the Circulation.

The graphic method introduced by Ludwig for the purpose of measuring the blood pressure was adapted by Volkmann to the registration of the pulse in man, and the same method has been modified and rendered more easily applicable at the bedside by Marey and Chauveau, to whom we chiefly owe our knowledge of the modifications in the form of the apex beat, and of the pulse curve. It is to Ludwig and his pupils, however, that we owe the greater part of our knowledge of the mechanism of the circulation, and of the varying distribution of the blood in various parts of the body.

The effect of emotion upon the heart was carefully noted by Harvey, who says:

For every affection of the mind which is attended with pain or pleasure, hope or fear is the cause of an agitation whose influence extends to the heart.[10]

Not only was Harvey well acquainted with the fact that the beats of the heart vary very much in strength and force, but he also knew that the circulation in various parts of the body may be very different at one and the same time. He says:

It is manifest that the blood in its course does not everywhere pass with the same celerity, neither with the same force in all places and at all times, but that it varies greatly according to age, sex, temperament, habit of body, and other contingent circumstances, external as well as internal, natural or non-natural. For it does not course through intricate and obstructed passages with the same readiness that it does through straight, unimpeded, and pervious channels. Neither does it run through close, hard, and crowded parts with the same velocity as through spongy, soft, and permeable tissues. Neither does it flow and penetrate with such swiftness when the impulse (of the heart) is slow and weak, as when this is forcible and frequent, in which case the blood is driven onwards with vigour and in large quantity. And what indeed is more deserving of attention than the fact that in almost every affection, appetite, hope, or fear, our body suffers, the countenance changes, and the blood appears to course hither and thither. In anger the eyes are fiery and the pupils contracted; in modesty the cheeks are suffused with blushes: in fear, and under a sense of infamy and of shame, the face is pale, but the ears burn as if for the evil they heard or were to hear; in lust how quickly is the member distended with blood and erected.[11]

But although these facts were known to Harvey so long ago, it is only in comparatively recent years that the mechanism by which they are brought about has been investigated; and it is only within the last decade that physiologists have begun regularly to believe that the cardiac muscle has a power of rhythmic pulsation independent of its nerves, although Harvey had noted that when the heart was cut into small pieces the fragments would still continue to pulsate. We may fairly, indeed, compare the movements of the heart, as regarded by physiologists of the present day, to those of a horse, which is capable of going independently although its pace may be slowed or accelerated by the reins or spur of the rider. The power of the vagus to act as a rein to the heart and slow its movements or stop them altogether was first noted by Edward and Ernest Heinrich Weber, while the effect that it sometimes has of accelerating instead of slowing, like the effect of shaking the reins of the horse, was observed by Schiff, Moleschott, and Lister.

The accelerating nerves of the heart were more thoroughly investigated by von Bezold, while the power of the vagus to weaken as well as slow the heart was observed by Gaskell. The position of the cardiac centre, which, like the rider, regulates the movements of the heart, was located in the medulla oblongata chiefly by Ludwig and his pupils.

The Vasomotor Apparatus.

Like the heart, the vessels also are regulated in diameter by the nervous system in accordance with the wants of the body generally, and the effect upon the vasomotor nerves—which when cut allow them to dilate and when stimulated cause them to contract—was discovered by Bernard, Brown-Séquard, and by our countryman, Waller; while the power of other nerves to cause immediate dilatation was discovered by Bernard, Eckhardt, and Ludwig in the submaxillary glands, penis, and peripheral vessels respectively.

Researches carried on under Ludwig's direction by various of his pupils in succession, Alexander Schmidt, Dogiel, Sadler, myself, Hafiz, Lépine, A. Mosso, von Frey, and Gaskell, as well as the observations of Cohnheim and Gunning, have shown that the muscular fibres of the arterioles, not only in the muscles but throughout the body generally, have a power of independent and sometimes rhythmical contraction and relaxation. Their contractility is, however, controlled by the central nervous system in accordance with the wants of the body generally. For the amount of blood contained in the body is insufficient to fill the whole of the vascular system at once, and when the vessels are fully dilated as they are after death, we find that nearly the whole of the blood of the body may be contained in the veins alone. It is, therefore, necessary that when one part of the body is receiving a larger supply of blood, another should be receiving a smaller supply; and the functions of the vasomotor centres have been well compared by Ludwig to the turncocks in a great city, who cut off the water supply from one district, at the same time they turn it on to another. Thus it is that when the brain is active the feet may get cold, and Mosso has shown this in an exceedingly neat manner by placing a man on a large board delicately balanced at its centre, and demonstrating that whenever the man began to

[8] *The Works of William Harvey*, Sydenham Society's Edition, p. 72.
[9] *The History of the Royal Society of London for the Improving of Natural Knowledge*. By Tho. Spratt, D.D., late Lord Bishop of Rochester.
[10] *The Works of William Harvey*, Sydenham Society's Edition, p. 70.
[11] *Ibid.*, pp. 124, 125.

think, the increased supply of blood to his brain caused the head to go down and the heels to rise up.

Ubi stimulus ibi affluxus was an old doctrine, and expressed a great truth. Wherever the need for increased nourishment or increased supply of oxygen exists in the healthy body, thither does the blood flow in larger quantities than usual. If the glands are active their blood supply is greatly increased, as was shown by Bernard, and a similar occurrence takes place in the contracting muscle, as has been shown by Ludwig and his pupils. The vessels of the intestines and of the skin, with their numerous glands, have their calibre regulated by the vasomotor nerves, which proceed from the centre in the medulla oblongata. This centre acts most readily upon the vessels of the intestines, and rather less readily on those of the skin. In consequence of this, when the centre is irritated the vessels of the intestine contract and drive the blood through the skin so that it is warmer than before, and it is only when the stimulation is very great that the vessels of both contract so that the skin receives less blood than normal and becomes colder than before. But if the vessels of the skin and intestine are both contracted, where does the blood go? This question was put by Ludwig, and answered by the experiments which he made with Hafiz. It is evident that if the heart be stopped while the blood pressure is being measured in the artery of an animal, the pressure will fall regularly and steadily, because the blood is flowing out all the time through the arterioles and capillaries into the veins. One would naturally expect that if the arterioles were contracted by irritation of the vasomotor centres in the medulla, the fall of blood pressure would either not take place at all or would be very much slower than before, but on trying the experiment Ludwig and Hafiz found, to their surprise, that the blood pressure fell almost as quickly as when the vasomotor centre was left alone and the vessels of the skin and intestine therefore remained uncontracted. In other words, the vessels which supply the muscles of the body and limbs are capable of such extension that when fully dilated they will allow the arterial blood to pour through them alone nearly as quickly as it usually does through the vessels of the skin, intestine, and muscles together. This observation, it seems to me, is one of the greatest importance, and one that has hardly received the attention which it merits. It is obvious that contraction of the cutaneous vessels, such as occurs upon exposure to cold, will drive more blood through the muscles, and as oxidation goes on more rapidly in them the result will be increased production of heat.

The Circulation and the Muscular System.

The experiments I have just mentioned show that the vessels of the muscles are not controlled by the vasomotor centre in the medulla oblongata in the same way as those of the intestine and skin. How far their vascular centres may be associated with those for voluntary movements, which have been so admirably localised by Ferrier in the cerebral cortex, still remains to be made out. The circulation through the muscles is, indeed, a complex phenomenon, and it was shown by Ludwig and Sadler to depend upon at least two factors having an antagonistic action. When a muscle is thrown into action it mechanically compresses the blood vessels within it, and thus tends to lessen the circulation through it, but at the same time the stimulus which is sent down through the motor nerve, and which calls it into action, brings about a dilatation of the muscular walls, and thus increases the circulation through the muscle.

When the amount of blood is measured before, during, and after stimulation of its motor nerves, it is sometimes found that the flow is diminished, at others that it is increased, the alteration depending upon the comparative effect of the mechanical compression of the vessels of the muscles just mentioned, and upon the increase of their lumen by the dilatation of their walls. It invariably happens, however, that after the muscle has ceased to act the flow of blood through the muscle has increased. This increase is quite independent of any alteration in the general pressure of blood in the arteries, and it occurs when an artificial stream of blood, under constant pressure, is sent through the muscle. The dilatation in the muscular vessels, as indicated by the increased flow of blood, and consequent change of colour in the frog's tongue, was observed by Lépine after stimulation of the peripheral ends of the hypoglossal and glosso-pharyngeal nerves, and the actual changes in the vessels themselves were observed microscopically by von Frey and Gaskell.

The dilatation of muscular vessels on irritation of peripheral nerves was thus brought into a line with the dilatation noticed in the vessels of the submaxillary gland by Bernard, and in the corpora cavernosa by Eckhardt. It is evident that alteration in the size of such a huge vascular tract as the muscular arteries must influence, to a great extent, the blood pressure in the arteries generally; and it is equally evident that the changes induced in the condition of the blood pressure by muscular action may be of two kinds—either a rise or a fall. If the arterioles are compressed by the muscles, so that the flow through them is impeded, the general blood pressure will rise. When this effect is more than counteracted by the dilatation of the arterioles themselves under nervous influence, the general blood pressure will fall, for the blood will find an easy passage through the vessels from the arteries into the veins. We can thus see how readily a rise or fall in the general blood pressure may be induced by exercise of the muscles. If they contract suddenly or violently they will tend to compress the arterioles, and raise the blood pressure, while quite easy contraction will have little effect in compressing the arteries, and these, becoming dilated, will allow the blood pressure to fall.

But there is still another factor which may tend to increase the blood pressure during severe muscular exertion, and this is the fact that stimulation of the nerve fibres extending from the muscles to the central nervous system greatly accelerates the beats of the heart. In this respect stimulation of the muscular nerves differs from that of the cutaneous and visceral nerves, inasmuch as the latter tend rather to slow than to quicken the pulse. The peculiar effect of the muscular nerves upon the heart would indeed appear to be a provision of Nature for the purpose of maintaining an exceedingly active circulation during the active calls upon nutrition which violent exertions entail. Muscular exercise, therefore, has a special tendency to raise the blood pressure in the arterial system, and consequently to increase the resistance which the left ventricle has to overcome. Moreover, in the case of the intestinal vessels there is a special provision made for preventing their contraction from causing too great a rise of arterial pressure. This consists in the depressor nerve, which passes from the heart and tends to produce dilatation of the abdominal vessels, and thus prevent any undue pressure occurring within the heart from their excessive contraction. In the case of the muscles we have no such nerve; its place seems to be taken by the dilating fibres which occur in the motor nerves. As I have already said, however, this effect of dilatation in the muscular vessels may be at first more than counteracted by mechanical compression at the commencement of exertion, and thus the blood pressure in the arteries and the resistance which it opposes to the contraction and emptying of the ventricle may be unduly increased.

As a general rule, the distension of any hollow muscular organ is attended with great pain. The heart is no exception to this rule, and distension of its cavities brings on most acute physical suffering. Its inability to empty itself is a question of relative, and not of absolute, power; for a strong heart may be unable to work against enormously increased resistance in the peripheral arterioles, while the heart, weakened by degeneration, may be unable to empty itself in face of pressure little, if at all, above the normal.

When the contractile power of the heart is not as it is in health, considerably in excess of the resistance opposed to it in vessels, but is nearly equal to it, a slight increase in the resistance may greatly interfere with the power of the heart to empty itself, and bring on pain varying in amount from slight uneasiness to the most intense agony in angina pectoris. This is, indeed, what we find; for a heart whose nutrition has been weakened by disease of the arteries and consequent imperfect supply of blood to the cardiac muscle is unable to meet any increased resistance if this should be offered to it, and pain is at once felt. In such cases unless they be far advanced we find, precisely as we might expect, that walking on the level usually causes no pain, but the attempt to ascend even a slight rise by which the muscles are brought into more active exertion brings on pain at once. Yet here again we find, as we should expect, that if the patient is able to continue walking, the pain passes off and does not return. These phenomena would be inexplicable were it not for Ludwig's observations on circulation through the muscles, but in the light of these observations everything is made perfectly intelligible. Walking on the flat, by causing no violent exertion of the muscles, produces no mechanical constriction of the vessels and thus does not increase the blood pressure. The greater exertion of walking up a hill has this effect, but if the patient is able to continue his exertions, the increased dilatation of the vessels—a consequence of muscular activity—allows the pressure again to fall and relieves the pain.

EFFECT OF MUSCULAR OVERWORK ON THE HEART.

As muscular exertion continues and the vessels of the muscles become dilated, the flow of blood from the arteries into the veins will tend to become much more rapid than usual. The pressure in the arterial system will fall consequently, but that in the veins will become increased, and, unless a corresponding dilatation occurs in the pulmonary circulation, blood will tend to accumulate in the right side of the heart, the right ventricle will be unable to empty itself completely, shortness of breath will arise, and even death may occur. At first the right side of the heart is affected, and the apex beat disappears from the normal place, and is felt in the epigastrium, but the left ventricle also becomes dilated, though whether this is simply through nervous influence tending to make it act concordantly with the right, or for some other reason, it is at present impossible to say. Severe exertion, even for a few minutes, may produce this condition in healthy persons,[12] and when the exertion is overcontinued it may lead to permanent mischief. More especially is this the case in young growing boys; and it is not merely foolish, it is wicked, to insist upon boys engaging in games or contests which demand a long-continued overexertion of the heart, such as enforced races, and paper chases extending over several miles. Intermittent exertion, either of a single muscle or of a group of muscles, or of the whole body, appears to lead to better nutrition and increased strength and hypertrophy, but overexertion, especially if it continues, leads to impaired nutrition, weakness, and atrophy. If we watch the movements of young animals, we find that they are often rapid, but fitful and irregular, and varied in character, instead of being steady, regular, and uniform. They are the movements of the butterfly, and not of the bee. The varied plays of childhood, the gambols of the lamb, and the frisking of the colt are all well adapted to increase the strength of the body without doing it any injury; but if the colt, instead of being allowed to frisk at its own free will, is put in harness or ridden in races, the energy which ought to have gone to growth is used up by the work, its nutrition is affected, its powers diminished, and its life is shortened. The rules which have been arrived at by the breeders of horses ought to be carefully considered by the teachers of schools, and by the medical advisers who superintend the pupils.

ANGINA PECTORIS.

In youth and middle age every organ of the body is adapted for doing more work than it is usually called upon to do. Every organ can, as it is usually termed, "make a spurt" if required, but as old age comes on this capacity disappears, the tissues become less elastic, the arteries become more rigid, and less capable of dilating and allowing freer flow of blood to any part, whether it be the intestine, the skin, the brain, the muscles, or the heart itself. Mere rigidity of the arteries supplying the muscles of the heart will lessen the power of extra exertion, but if the vessels be not only rigid but diminished in calibre, the muscles of the limbs and the heart itself will be unfit even for their ordinary work, and will tend to fail on the slightest over-exertion. This fact was noticed by Sir Benjamin Brodie, who, when speaking of patients with degenerating and contracted arteries, such as lead to senile gangrene, said:

> Such patients walk a short distance very well, but when they attempt more than this the muscles seem to be unequal to the task, and they can walk no further. The muscles are not absolutely paralysed, but in a state approaching to it. The cause of all this is sufficiently obvious. The lower limbs require sometimes a larger and sometimes a smaller supply of blood. During exercise a larger supply is wanted on account of the increased action of the muscles; but the arteries being ossified or obliterated, and thus incapable of dilatation, the increased supply cannot be obtained. This state of things is not peculiar to the lower limbs. Wherever muscular structures exist the same cause will produce the same effect. Dr. Jenner first, and Dr. Parry, of Bath, afterwards, published observations which were supposed to prove that the disease which is usually called angina pectoris depends on ossification of the coronary arteries.........When the coronary arteries are in this condition they may be capable of admitting a moderate supply of blood to the muscular structure of the heart; and as long as the patient makes no abnormal exertion the circulation goes on well enough. When, however, the heart is excited to increased action, whether it be during a fit of passion, or in running, or walking upstairs, or lifting weights, then, the ossified arteries being incapable of expanding so as to let in the additional quantity of blood which under these circumstances is required, its action stops and syncope ensues; and I say that this exactly corresponds to the sense of weakness and want of muscular power which exists in persons who have the arteries of the legs obstructed or ossified.[13]

But the syncope and stoppage of the heart mentioned by Brodie are not the only consequences of impaired cardiac nutrition. The heart may be still able to carry on the circulation, but the patient may suffer intense pain in the process. The outside of the heart was found by Harvey to be insensible to light touches, but the inside of the heart appears to be much more sensitive either to touch or pressure.

PRINCIPLES OF TREATMENT OF HEART DISEASE.

A knowledge of the mode of circulation of blood through the muscles enables us to understand not only the pathology of angina pectoris but the *rationale* of various methods of treating patients suffering from angina pectoris or other forms of heart disease. In most cases our object is a twofold one—to increase the power of the heart and to lessen the resistance it has to overcome. In some cases we require also to aid the elimination of water which has accumulated so as to give rise to œdema of the cellular tissues or dropsy of the serous cavities. In our endeavours to produce these beneficial changes in our patients, we employ regimen, diet, and drugs, and it is evident that in cases where the condition of one patient's heart may be very different indeed from that in another, the regimen which may be useful to one may be fatal to the other. We have already seen that sudden and violent exertion may raise the blood pressure, and so lead to intense cardiac pain or to stoppage of the heart and instant death; while more gentle exercises, by increasing the circulation through the muscles, may lessen the pressure and give relief to the heart.

The methods of increasing the muscular circulation may be roughly divided into three, according as the patient lies, stands, or walks. First, absolute rest in bed with massage; secondly, graduated movements of the muscles of the limbs and body while the patient stands still; thirdly, graduated exercises in walking and climbing.

The second of these methods has been specially worked out by the brothers Schott, of Nauheim, and the third is generally connected with the name of Oertel.[14]

ABSOLUTE REST.

It is obvious that in cases of heart disease where the failure is great and the patient is unable even to stand, much less to walk, where breathlessness is extreme, and dropsy is beginning or has even advanced, the second and third methods of treatment are inapplicable. It is in such cases that the method of absolute rest in bed, not allowing the patient to rise for any purpose whatever, hardly allowing him to feed himself or turn himself in bed, proves advantageous. The appetite is usually small, the digestion imperfect, and flatulence troublesome, and here an absolute milk diet, like that usually employed in typhoid fever, is often most serviceable, being easily taken and easily digested, while the milk sugar itself has a diuretic action and tends to reduce dropsy.

MASSAGE.

But while simple rest prevents the risk of increased arterial tension and consequent opposition to the cardiac contractions which might arise from muscular exertion, such benefit as would accrue from muscular exertions and increased circulation would be lost were it not that

[12] Schott's *Verhandl.*, d. ix Congresses in Med. zu Wien, 1890.

[13] *Lectures on Pathology and Surgery.* By Sir Benjamin Brodie. London, 1846, p. 360.

[14] *Practitioner*, vol. li, p. 190.

they can be supplied artificially by massage. This plan of treatment, although it has only recently been revived, was known to Harvey, who narrates the case of a man who, in consequence of an injury, of an affront which he could not revenge, "was so overcome with hatred, spite, and passion, that he fell into a strange disorder, suffering from extreme compression and pain in the heart and breast, from which he only received some little relief at last when the whole of his chest was pummelled by a strong man, as the baker kneads dough."[15]

This was a very rough form of massage, but the same kneading movements which he described have been elaborated into a complete system, more especially by Ling, in Sweden, and made widely known in America and this country by Weir Mitchell and Playfair. One might naturally expect that kneading the muscles would increase the circulation through them in somewhat the same way as active exercise, but, to the best of my knowledge, no actual experiments existed to prove this, and I accordingly requested my friend and assistant, Dr. Tunnicliffe, to test the matter experimentally. The method employed was, in the main, the same as that devised by Ludwig, and employed by Sadler and Gaskell under his direction. The results were that during the kneading of a muscle the amount of venous blood which issued from it was sometimes diminished and sometimes increased; that just after the kneading was over the flow was diminished, apparently due to accumulation of blood in the muscle, and again succeeded by a greatly increased flow exactly corresponding with that observed by Ludwig and his pupils.

The clinical results are precisely what one would expect from increased circulation in the muscles, and cases apparently hopeless sometimes recover most wonderfully under this treatment.

GRADUATED MUSCULAR EXERCISE.

For patients who are stronger, so that confinement to bed is unnecessary, and who yet are unable to take walking exercise, Schott's treatment is most useful, and it may be used as an adjunct to the later stages of the treatment just described, or as a sequel to it. Here the patient is made to go through various exercises of the arms, legs, and trunk, with a certain amount of resistance which is applied either by the patient himself setting in action the opposing muscles, or by an attendant, who gently resists every movement made by the patient, but graduates his resistance so as not to cause the least hurry in breathing, or the least oppression of the heart. Perhaps the easiest way of employing graduated resistance is by the ergostat of Gärtner, which is simply an adaptation of the labour crank of prisons, where the number of turns of a wheel can be regulated in each minute, and the resistance applied by a brake, and may be graduated to an ounce. The objection to it is the uniformity of movement and its wearisome monotony. Oertel's plan of gradually walking day by day up a steeper and steeper incline, and thus training the muscles of the heart, is well adapted for stronger persons; but, when applied injudiciously, may lead—just like hasty or excessive exertion—to serious or fatal results. In all these plans the essence of treatment is the derivation of blood through a new channel, that of the muscular vessels, and the results in relieving cardiac distress and pain may be described in the same words which Harvey employs in reference to diseases of the circulation:

> How speedily some of these diseases that are even reputed incurable are remedied and dispelled as if by enchantment.[16]

CHEMISTRY OF THE CIRCULATION.

There is yet another consequence of the circulation to which Harvey has called attention, although only very briefly, which has now become of the utmost importance, and this is the admixture of blood from various parts of the body. After describing the intestinal veins, Harvey says:

> The blood returning by these veins, and bringing the cruder juices along with it—on the one hand from the stomach, where they are thin, watery, and not yet perfectly chylified; on the other, thick and more earthy, as derived from the fæces, but all pouring into this splenic branch—are duly tempered by the admixture of contraries.[17]

Harvey's chemical expressions are crude, for chemistry as a science only began to exist about a century and a-half after Harvey's death, yet the general idea which he expresses in the words which I have just quoted is wonderfully near the truth.

The most important constituents of the blood are chloride of sodium and water. Chloride of sodium is a neutral salt, but during digestion both it and water are decomposed in the gastric glands and hydrochloric acid is poured into the stomach while a corresponding amount of soda is returned into the blood, and its alkalinity increases *pari passu* with the acidity of the stomach. Part of this alkali is excreted in the urine so that the urine during digestion is often neutral or alkaline, and possibly some of it passes out through the liver with the bile of the pancreas and intestinal juice, where, again mixing with the chyle from the stomach, neutralisation takes place, so that neutral and comparatively inactive chloride of sodium is again formed from the union of active alkali and acid. But it is most probable that what occurs in the stomach occurs also in the other glands, and that it is not merely excess of alkali resulting from gastric digestion which is poured out by the liver, pancreas, and intestine, but that these glands also decompose salts, pour the alkali out through the ducts and return the acid into the blood.

We are now leaving the region of definite fact and passing into that of fancy, but the fancies are not entirely baseless, and may show in what direction we may search out and study the secrets of Nature by way of experiment; for what is apparently certain in regard to the decomposition of chloride of sodium in the stomach and probably in the case of neutral salts in the pancreas and intestine, is also probable in that important, though as yet very imperfectly known, class of bodies which are known as zymogens. Just as we have in the stomach an inactive salt, so we have also an inactive pepsinogen which, like the salt, is split up in the gastric glands and active pepsine is poured into the stomach. But is the pepsine the only active substance produced? Has no other body, resulting from decomposition of the pepsinogen, been poured into the blood while the pepsine passed into the stomach? Has the inactive pepsinogen not been split up into two bodies active when apart, inactive when combined? May it not be fitly compared, as I have said elsewhere, to a cup or glass, harmless while whole, but yielding sharp and even dangerous splinters when broken, although these may again be united into a harmless whole?

This question at present we cannot answer, but in the pancreas there is an indication that something of the kind takes place, for Lépine has discovered that while this gland pours into the intestine a ferment which converts starch into sugar, it pours through the lymphatics into the blood another ferment which destroys sugar. Whether a similar occurrence takes place in regard to its other ferments in the pancreas or in the glands of the intestine we do not know, nor do we yet know whether the same process goes on in the skin and whether the secretion of sweat, which is usually looked upon as its sole function, bears really the relationship to cutaneous activity which the secretion of bile bears to the functions of the liver. There are indications that such is the case, for when the skin is varnished not only does the temperature of the animal rapidly sink, but congestion occurs in internal organs, and dropsy takes place in serous cavities, while in extensive burns of the skin rapid disintegration of the blood corpuscles occurs.

THERAPEUTICAL DEDUCTIONS.

It is obvious that if this idea be at all correct a complete revolution will be required in the views we have been accustomed to entertain regarding the action of many medicines. In the case of purgatives and diaphoretics, for example, we have looked mainly at the secretions poured out after their administration, whereas it may be that the main part of the benefit that they produce is not by the substances liberated through the secretions they cause, but returned from the intestine and skin into the circulating blood.

MEDICATION BY ORGANIC JUICES.

How important an effect the excessive admixture of the juices from one part of the animal body with the circulating blood might have was shown in the most striking way by Wooldridge. He found that the juice of the thyroid gland,

[15] *The Works of William Harvey*, Sydenham Society's Edition, p. 128.
[16] *Ibid.*, p. 141.
[17] *Ibid.*, p. 75.

injected into the blood, would cause it to coagulate almost instantaneously, and kill the animal as quickly as a rifle bullet. What is powerful for harm is, likewise, powerful for good in these cases, and the administration of thyroid juice in cases of myxœdema is one of the most remarkable therapeutic discoveries of modern times. Since the introduction by Corvisart of pepsine as a remedy in dyspepsia, digestive ferments have been largely employed to assist the stomach and intestine in the performance of their functions, but very little has been done until lately in the way of modifying tissue changes in the body by the introduction of ferments derived from solid organs. For ages back savages have eaten the raw hearts and other organs of the animals which they have killed, or the enemies they have conquered, under the belief that they would thereby obtain increased vigour or courage; but the first definite attempt to cure a disease by supplying a ferment from a known glandular organ of the body was, I believe, made in Harvey's own hospital by the use of raw meat in diabetes.[15] It was not, however, until Brown-Séquard recommended the use of testicular extract that the attention of the profession became attracted to the use of extracts of solid organs. Since then extract of thyroid, extract of kidney, extract of suprarenal capsule have been employed, but even yet they are only upon their trial, and the limits of their utility have not yet been definitely ascertained.

MEDICATION BY ANTITOXINS.

But yet another therapeutic method has recently been introduced which bids fair to be of the utmost importance, the treatment of disease by antitoxins. The discovery by Pasteur of the dependence of many diseases upon the presence of minute organisms may be ranked with that of Harvey, both in regard to the far-reaching benefits which it has conferred upon mankind and for the simplicity of its origin. "Why does a crystal of tartaric acid sometimes crystallise in one form and sometimes in another?" These minute organisms, far removed from man as they are in their structure and place in Nature, appear in some respects to resemble him in the processes of their growth and nutrition. They seem, indeed, to have the power of splitting up inactive bodies into substances having a great physiological or chemical activity. From grape sugar, which is comparatively inert, they produce carbonic acid and alcohol, both of which have a powerful physiological action. From inert albumen they produce albumoses having a most powerful toxic action, and to the poisonous properties of these substances attention was for a while alone directed; but it would appear that at the same time that they produce poisons they also form antidotes, and when cultivated without the body and introduced into the living organism they give rise to the production of these antidotes in still greater quantity, and by the use of antitoxin tetanus and diphtheria appear to be deprived of much of their terrible power.

The plan of protection from infective diseases which was first employed by Jenner in small-pox is now being extended to many other diseases, and the protective substances which are formed in the body and the mode of action is being carefully investigated. The introduction of either the pathogenic microbe or of toxic products appears to excite in the body a process of tissue change by which antitoxins are produced, and these may be employed either for the purpose of protection or cure. It was shown by Wooldridge that thyroid juice has a power of destroying anthrax poison, and it seems probable that increase of the circulation of certain organs will increase their tissue activity, and thus influence the invasion or progress of disease. As I have already mentioned, we are able to influence the circulation in muscles both by voluntary exertion and by passive massage, and we should expect that both of these measures would influence the constituents of the blood generally, and such, indeed, appears to be the case; for J. K. Mitchell has found that after massage the number of blood corpuscles in the circulation is very considerably increased.

Had time allowed it I had intended to discuss the modifications of the heart and vessels by the introduction of remedies into the circulation, the power of drugs to slow or strengthen, to quicken or weaken the power of the heart, to contract or relax the arterioles, to raise or lower the blood pressure, to relieve pain or to remove dropsy, but to do this would require time far exceeding that of a single lecture. Moreover, the methods and results were admirably expounded to the College by Dr. Leech in his Croonian Lectures; and I have therefore thought I should be better fulfilling the wish of Harvey that the Orator of the year should exhort the Fellows and Members of the College to search out the secrets of Nature by way of experiment by directing their attention to fields of research which have received at present little attention, but promise results of great practical value.

[15] BRITISH MEDICAL JOURNAL, February 21st, 1874, p. 221, *et seq.*

AN ADDRESS

DELIVERED AT THE OPENING OF

THE SECTION OF SURGERY.

At the Annual Meeting of the British Medical Association at Bristol, August, 1894.

BY W. MITCHELL BANKS, M.D., F.R.C.S.,
Surgeon to the Liverpool Royal Infirmary.

ON THE LOVE OF NOVELTY.

GENTLEMEN,—It is not my duty to deliver to you to-day any elaborated or formal address. The Address in Surgery, to which we are all looking forward with pleasurable anticipation, does away with any such necessity. But I may be allowed to offer to you a very hearty welcome, and to express the hope that the important surgical questions which we purpose discussing in this room during the next three days will have much light thrown upon them by the several experiences which you will bring to bear upon them. To have been chosen as your President I regard as one of the highest distinctions that has fallen to my lot, and I trust that when our sitting has ended we shall all carry away with us happy remembrances, not only of pleasant holiday and hospitality, but of useful and serious work.

Advancing years, while they rob us of many delights and somewhat cruelly sweep away many of the happy expectations of youth, leave to some of us the great advantage of being able to look behind us along the path by which we have travelled, while still seeing before us a goodly stretch of that high road to the mountains of perfection which we may never reach, but upon which the eyes of every true man are fixed from the very day on which he commences life's journey.

A few months ago, in a recent number of the *Medical Magazine*, I read a review of Mr. Jacobson's lives of two famous Guy's surgeons—John Hilton and Edward Cock. The reviewer commenced his notice with these sentences:

"It is too much the fashion among the younger generation of professional men to associate eminence in surgery with some new method of procedure or some brilliant achievement in the way of an operation never thought possible. It is not remembered that the day after to-morrow the method will be supplanted by another, the operation will be discarded as useless or unjustifiable. In surgery, as in medicine, true greatness consists rather in the power of applying a wide and accurate knowledge to the elucidation of the numberless problems suggested by an extended clinical experience, in maintaining that balance of judgment which can withstand the temptations to adventurous brilliancy without becoming stagnated in the slough of servile adherence to tradition. If we look back at the history of surgery it will be found that the men who have left their mark are not the brilliant operators or learned investigators, but rather men who continually devoted great ability to the work of their profession, to the solution of the questions which daily presented themselves for interpretation. They were men who spared no pains in their work, who shirked no difficulties, but they were men who ever placed the patient in the first place, and looked upon operative brilliancy as a means to an end."

As my thoughts went back along the seven-and-twenty years during which I have been engaged in active surgical work, I began to recall the many surgeons whom I have known during that not inconsiderable period, and I came to the conclusion that there was a great deal of truth in these