INTRODUCTORY ADDRESS ON THE ELECTROMOTIVE PROPERTIES OF THE HUMAN HEART.

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By AUGUSTUS D. WALLER, M.D.,
Lecturer on Physiology.

THERE is a growing disposition to regard introductory lectures as a survival—a survival unfit for the times. But, like all other customs, this custom, having had its particular reason of being in the past, lives on with altered ends and in changing shape. In its primitive shape, as a general guidance address to those who have just enlisted, it may be no longer necessary nor acceptable, but it certainly cannot be unfitting in any time that each member of a teaching body should in turn be called upon to say, in the presence of his fellow-workers, that which he thinks to be the best worth saying. My particular task on this occasion has been made easy by my colleagues; it was suggested to me that I should speak about physiology, and I am very willing to do so. Let me at once explain why.

The St. Mary's Hospital Medical School is at present rapidly growing, not merely in size, but in complexity; and she has within the last few years developed two entirely new organs, a physiological and a pathological laboratory. It is not unnatural that those who are most responsible for the development should be glad to hear something about the functions of these organs, and should expect from me as the person responsible for the physiological laboratory some report of progress during the last four years. I am on my side very willing that my duty as your introductory lecturer should take this form, which will allow me, not, indeed, to report progress in its full and formal sense, but to report on an item of progress; and I shall, therefore, occupy the greater part of the thirty or forty minutes allowed me, in describing a new bit of knowledge, and how it has been obtained. Our new bit of knowledge is about the human heart, not in a metaphysical or figurative sense, not its motives, but only its action, not its power, but its electrical potential. Put into a single sentence, I am going to describe how the heart of man can be shown to act as an electrical organ, and what we learn from such action.

It is a well-known fact that every beat of the heart is accompanied by an electrical disturbance; the nature of this disturbance has, moreover, been studied and understood with the assistance of cold-blooded animals, and in this laboratory in particular an investigation was carried out to learn whether or no warm-blooded animals manifest similar electrical disturbances. These I will not now enter upon, and will only make the passing remark that, while to all appearance the electrical disturbances are similar in the two classes of animals, they are not identically so; these seem to indicate that the contraction, which at each beat of the cold-blooded heart runs down from the base to the apex, runs in the opposite direction in the warm-blooded heart. But this is only by the way, and I make no attempt to explain. It is to the next step that I invite your attention to-day, namely, to the human heart.

Led on from thought to thought it occurred to me that it should be possible to get evidence of electrical action on man by connecting not the heart itself, which is obviously impossible, but parts of the surface of the body near the heart with a suitable instrument; having verified this supposition, the next step was to see whether or no the same evidence can be obtained by connecting the instrument with parts of the body at a distance from the heart, with the hands or feet. The answer was, as you will see, satisfactory. Finally, I tried whether two people holding hands and connected with the instrument, gave evidence of electrical shocks through each other, and I found they did.

The only portion which I wish to explain in any detail is the second step in these experiments, namely, the analysis of the results which are obtained when a single individual, whether man, horse, or dog, is connected with the electrical indicator.

Let me briefly explain the principle of action of an electrical indicator by referring to this diagram, in which the effects of water-pressure are compared with those of what I may call electrical pressure (potential is the correct term, but I take it to be part of my task to-day to avoid technical terms).

A and B are two bottles of water, each connected by flexible pipes with a bent tube half full of mercury. If the two bottles are at the same level, the mercury in the bent tube remains at zero, and it is evident that this is still the case if both bottles be raised together or lowered together. But if the bottles be moved unequally, either up or down, the level of the mercury will alter. It is obvious that if A is lower than B, the mercury in this limb of the tube will move upwards, whereas if B is lower than A it will move downwards. And if we imagine everything hidden from us by a screen with the exception of this portion of the tube which we can view through a circular opening, while the two bottles are being moved by unseen hands, it is obvious that we shall be able to tell by the movements of the index, whether A is below B or B below A. If the mercury goes up A is below B, if it goes down B is below A.

Now this is precisely what happens when the two ends of an electrical indicator are in connection with any two points A and B of a living body. If A and B are at the same level the index stands at zero, and it does not move if the two points are raised or lowered together to an equal amount. If the index moves up we know that A is lower than B, if down that B is lower than A.

Let us now apply our instrument to the heart. This, which seems rather a bold proposition, is really a very simple and easy matter. We need simply dip the two hands into two basins of water which are in connection with our indicator, when we shall see that the mercury beats up and down with the pulse. These movements of the mercury are due to the electrical changes which occur with every beat of the heart: or we may dip a hand and a foot each into a basin of water with a similar result, only it must be the right hand, the left will not do. This difference, apparently so curious and puzzling at first sight, which seemed unsymmetrical and irrational, is in reality most reasonable, and

proved to be the master key which threw open the meaning of every subsequent experiment. The difference depends upon the unsymmetrical position of the human heart, which is tilted to the left side somewhat, as shown in this diagram.

Allow me to return for one moment to the physical A B C of the subject. The points A and B are respectively applied to the apex and base of the heart; and if with the contraction of the organ these two portions undergo any electrical change, the change will spread over the whole body in accordance with known laws. I will say no more than that. The form of the change is represented by these oval lines; if the electrical level falls at A it falls over the red area (see note and fifth diagram), which, as you see, includes the left hand and foot and the right foot. If the electrical level falls at B it falls over this blue area, which includes the right arm and the head.

Now it is obvious that the two ends of the indicator must be connected with A and with B before it will indicate any difference between A and B. If both ends are connected with A, or both ends with B, nothing will be seen. This was precisely what we got when the left hand and a foot were connected with the instrument, which begins to pulsate as soon as the right is substituted for the left hand. I might multiply instances, but will only just mention one. If the mouth and right hand are connected with the instrument, its index does not move, but it does so as soon as the left hand is put in the place of the right one. You must connect up a blue and a red point; two blue points or two red points are ineffectual.

But this evidence does not stand alone. Cases every now and then present themselves with a transposition of the viscera, which are in such people situated just like those of a normal person as they would be viewed in a mirror. The heart, among other organs, is reversed, and, instead of pointing to the left, points to the right. As regards the electrical relations which I was following out, they were precisely as expected. The left arm was in this case the exceptional limb, and formed an effectual couple with any one of the other three limbs, but was ineffective in combination with the mouth. To make a long story short, the results were throughout as indicated in the diagram: any two blue points or any two red points in connection with the indicator were silent, but as soon as connection was made with a red point and a blue point then the index moved with each pulsation of the heart.

Let us hear one more witness. The heart of a quadruped (dog, or cat, or rabbit, or horse) is placed far more symmetrically than in man: it is very nearly in the middle line, so that the changes of electrical level whose foci are at A and B spread straight up and down the body, not obliquely, as in man. The upper half of the body is under the influence emanating from B; the lower half under that emanating from A. Unlike what occurs in man, the

two front paws coupled with an indicator are silent, while either front paw taken with either hind foot gives us the now familiar answer.

These are the principal facts. What can we learn from them with regard to the normal action of the heart? I must be content with simply stating the answers.

The fact that each beat of the heart gives an electrical change, beginning at one end of the organ and ending at the other, proves that the contraction does not occur throughout the mass of the heart at one and the same instant of time; if the two points A and B rose and fell together, there would be no alteration of the index. The movements of the index show that there is a fall of A at the beginning of the contraction, and a fall of B at the end of

the contraction. One of the most fundamental and certain facts in physiology is that the active state of a living tissue is marked by a fall of electrical level; in other words, an electrical depression is the best, most certain, and most delicate physical sign of physiological action; it proves the fact that living tissue is in excitement just as certainly as a dog's bark proves that a living

dog is in excitement; A barks first, B barks last. In the contraction of the human heart the beat begins at the apex and ends at the base.

We have here the answer, and more than the answer, to a question which has often been asked but never settled, namely, does the heart (that is, the ventricles) beat simultaneously in every portion, or does the contraction take place progressively, as a state of action traversing the whole mass from a beginning to an end? The answer is a distinct affirmation of the second alternative to the exclusion of the first, with the additional and unexpected rider that the contraction begins at the apex and terminates at the base.

CC = cardiogram. EE = electrometer tracing. tt = time in tenths of a second.

I have tried to sketch out in language as little technical as might be the scope and outcome of a physiological research. I fear—nay, I am sure—that to many of my audience it has been

dry and tedious, yet I cannot but hope that some of you have been interested to hear by an actual example what kind of work goes on inside a physiological laboratory. That has been on the learning side. I should like to touch upon the teaching side.

We may take for granted the importance of physiology in medical education; you have, apart from all higher considerations, a very prominent and tangible sign in the still growing requirements of every examining board, on the Embankment as well as at Burlington House.

Your chief stumbling-block is in the indefiniteness of the subject. You are expected to show that you understand certain sequences and relations between the chief functions of the human body, and that you remember a list of facts, laws, numbers, formulae, and German opinions. Now it generally happens, when a man sends in his schedules, that he distrusts his memory rather than his understanding; but I am well assured that failures are far more due to unconscious errors of understanding than to conscious errors of memory. What I have termed the sequences and relations in physiology are the silent river; the strings of letters, figures, and words are the brawling torrent! This is exactly as it should be, for the silent stream is a better test of a man's swimming capacity than the shallow torrent.

To drop metaphor—the great sequences and relations between the parts of a living body, by their very indefiniteness, form the best possible ground on which to test judgment and acumen before memory, just the qualities by which you will have some day to distinguish, weigh, and guide physiological factors which hang together labelled with the name of a disease.

If you learn to see clearly and to move freely in the half-lights of physiology, you will see better and blunder less when you have to act in the quarter lights of medicine.

I do not intend to refer in any great detail to particular examinations, but, still confining myself to physiology, I will allude to them for a particular purpose. The first and second examinations of the Conjoint Board are the first two tests which you all submit to, and I think it is becoming more and more your custom not to give a very bulky precipitate of failures from St. Mary's. I gather from the dean's statistics that the St. Mary's share of the precipitate is very small in comparison with that which it contributes to the filtrate. Taken all in all the tests are reasonable; the quality of book knowledge and of practical work required is sensible and moderate.

But, London? It would appear as if the regulations for the intermediate M.B. were designed with the special purpose of preserving the ordinary London graduate from any practical acquaintance with physiology. The regulations set forth that practical work in physiology is required only by candidates for honours, and not by candidates for the ordinary pass. A little further, under the heading of organic chemistry, they supply the astonishing item of information that an estimation of sugar or of urea may be required in the honours examination.

As if still further to ensure that the ordinary candidate may have a fair chance of muddling his physiology by neglecting it in season and cramming it out of season, when his whole attention should be concentrated on medicine and surgery, the regulations provide that "any candidate shall be allowed . . . to postpone his examination in physiology . . . until the next or any subsequent year."

The effect of these regulations upon the study of physiology is very unfavourable. You know only too well that practical physiology is not wanted at the examination, and you do not believe that it is wanted for the examination quite apart from any ulterior value it may possess to you. You look upon practical physiology as a luxury and you do without it. You are told that an estimation of urea or of sugar may be required at the honours examinations, what more natural than that a pass candidate should think it ridiculous waste of time to learn to estimate sugar and urea by doing so when he can read about it in any book? But I would have you remember this, that although the London University by implication advises you so badly, yet it does not expect you to act upon the advice—quite the contrary. Although as a matter of convenience, practical work is not wanted at the pass examination, there is no examination at which its value is more felt, both in the written paper and still more at the *viva voce* interview which follows it. The reason is obvious; the examiners you have the pleasure of meeting there are men whose lives are spent in laboratories, and whose conversation when you meet them at Burlington House is apt to be more practical than scholastic. To put it low, book talk, unleavened by any memo-

ries of the laboratory, does not pay; and as for the written paper well, fireside anatomists are not apt to give very clear or very correct descriptions; fireside physiologists write perfect balloons of unsubstantial statements.

I have seemed to make examinations the end-all of your students' career, but I need hardly say that I look beyond them; the proof of a picture is in the selling of it; the proof of a student is in the passing of him. These are rough tests which mark out good pictures and competent men. I should hardly have made such a point of practical physiology had I not been convinced that its importance extends beyond as well as up to the time when a man receives his certificate of competency to take charge of lives and limbs.

I would have you convinced from the very outset of your medical studies that examinations and competency in after life are on the same lines—the same road leads to both, and to the success which is the natural and lawful reward of competency. It is the royal road of actual contact with facts which temper men as fire tempers steel. Your way lies through the dissecting room, the laboratory, and the hospital ward, more than through the lecture room and the printed book. It is something, no doubt, to be learned, to be well filled with the knowledge of what other men have thought, said, and done; but mere learning is an invertebrate; contact with facts gives it backbone, and makes all the difference between the bookworm and mental vertebrate man. And it is the same royal road that leads on to that well-grounded consciousness of power, to that fertility of practical resource in the face of danger; above all, to that "never say die" spirit, which is the best of drugs—best for your patients, best for their doctors, best, indeed, for every man and woman with duties and purposes to fulfil.

Note.—The diagrams used in the lecture were in red and blue. In the woodcuts as printed, red is light shading, blue is dark shading. In the third diagram red is in plain lines, blue in dotted lines.

INTRODUCTORY ADDRESS ON THE PRESENT POSITION OF UNIVERSITY EDUCATION IN LONDON.

*Delivered at King's College at the Opening of the Session
1888-89.*

By J. E. ERICHSEN, F.R.C.S., F.R.S., LL.D.,
President of University College.

IN looking back through a somewhat lengthened professional career, Mr. Erichsen said that he could mark no incident in it that had given him more unmixed gratification than that of having been asked to preside on that occasion. It was not only that he felt it an honour, although he was well aware that the honour was not personal to himself, but that it was conferred upon him in virtue of that office which he held in a sister college as President of University College, and that the honour was, as it were, transmitted to him through that office of President and through that College over which he had the honour of presiding. In the name of that College he asked to be allowed to say how thoroughly it appreciated the honour that had been done to it through one of its officers.

But there was another source of deep gratification in his being present as President of University College, because it was an evidence, if any were needed, that those lines which once deeply and somewhat widely separated those two Colleges, University and King's, had now been obliterated. That change, and he thought he might say that advance, in public opinion which had marked the last half century had enabled two institutions (which at their origin differed so much as almost to be antagonistic) to assume a position of complete harmony. That harmony, as their Principal stated, had been brought about in a great measure by the co-operation of the two institutions in what he could not but think was one of the noblest and greatest educational works that had ever been attempted in this metropolis, namely, an endeavour to establish for the first time in the history

of London a Teaching University not only in, but for, London. It would, he said, ill become him to enter at any length into this question, inasmuch as they were all aware that a Royal Commission had been sitting for some months past, and was still in session, in order to consider the advisability of acceding to a petition that the two Colleges thought fit, in conjunction with other Institutions, to present to the Crown. But as he knew there was a great deal of misconception in the public mind, not only in the medical profession but in the mind of the public generally, upon this question of a new university for London, and as this might be the last time that he would have an opportunity of saying a word upon the subject in public before they received the report of that Commission which they were anxiously looking forward to, he might, perhaps, be allowed to say a few words in explanation of the position of the two Colleges in connection with the proposed Albert University.

It had long been felt by those who were interested in the cause of education in London that the sons and daughters of Londoners suffered much by the impossibility of receiving a thorough university education within the metropolis itself, and that it was necessary for them to go to institutions distant from their own homes in pursuit of the education which they desired. It was also felt—and especially in connection with the medical profession—that a great grievance existed in respect to the impossibility of those students who were educated in London receiving the much-coveted M.D. degree in connection with the schools in which they were educated, or only with very considerable difficulty and loss of time in the metropolis itself at all, and that it was necessary for them to go to distant or to foreign universities in order to receive such a degree. An Association outside the two Colleges, consisting of men much interested in educational matters, many of great learning and of great scientific repute, had been formed, and was presided over by a gentleman who in all probability was better cognisant of the requirements of medical students, so far as educational purposes were concerned, than any man living—he meant the President of the General Medical Council. That Association placed itself in communication with University and King's Colleges, and in consequence of the negotiations so opened up, those two Colleges joined in the views of that Association, and presented a petition to the Crown to enable them to take university rank, to give a university education, and to confer university degrees upon students in this metropolis. But they did not wish to do so alone and unaided. Neither of the Colleges had the slightest feeling of selfish interest in this matter. They were willing to sacrifice their own individuality, and they were anxious to associate themselves with the recognised medical schools in the metropolis on an equal and equitable footing, with the view of carrying out the object they had in view.

The governing bodies of the two Colleges felt that these great institutions had attained a position that gave them a perfect right to solicit from the Government that university rank should be conferred upon them, inasmuch as they stood in every respect upon an equal footing with the majority of the universities in the United Kingdom. Conjointly these two Colleges were founded some sixty years ago at a cost of considerably more than half a million of money. Conjointly they possessed an income from fees of something like £70,000 a year; conjointly they possessed trust funds to the extent of several hundreds of thousands of pounds for the endowment of lectureships, of scholarships, and prizes of various kinds. Each possessed in itself every requisite for a complete system of university education, a complete organisation of faculties, a faculty of arts, of laws, of science, and of medicine, and in that institution a department of theology. Each was connected with a large boys' school, and so far as the medical department was concerned, each College had a clinical hospital associated with it. Taking then the size of the two institutions, their wealth, their endowments, and their general position as educational establishments, the governing bodies of the two Colleges felt that they were fully justified in asking and petitioning that university rank might be conferred upon them. What the result of the deliberations of the Commission would be it was, of course, impossible for him or anyone outside of it to say, but they could only hope that the Commission might be favourably inclined to the petition which had been presented to the Crown by the evidence which had been brought before it. Without going further into this matter there was only one point which he wished to call attention to, and it was that, if the petition were granted, if university rank were accorded to the two Colleges in connection with the medical schools in London, they would be able to start at once with a