ORIGINAL COMMUNICATIONS.

THE RELATION OF PHYSIOLOGY TO THE TEACHING PROFESSION.

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I can conceive of no calling the exercise of which involves greater responsibilities in matters of conduct—physical, intellectual, moral—than that of the Teacher. At the same time, I know of no one science the discoveries and truths of which relate more intimately to these same matters of conduct—physical, intellectual, moral—than physiology, so that there seems to me a peculiar fitness in a physiologist being asked to address you. Though Professor Edgar might have found one with a larger experience of the great problems awaiting consideration, I venture to say he could have found no one more fully alive than I am to the importance of those subjects common to the physiologist and to the educationist.

The profession which you intend to adopt, as noble as it is responsible, consists in the judicious directing of the human being through the most critical stages in his or her development; it is, or it ought to be, the scientific guidance of the growth of the physical, intellectual, and moral faculties of the human organism from a time not long after the dawn of intelligence to the time when the era of independent action has arrived. Not that every one of you will have to direct all those stages of growth, the early as well as the late; but whichever it be that falls to your lot, the responsibility is there, and perhaps the greater the earlier the growth-stage which you find yourself called upon to direct. Education is the scientific guidance of growth—guidance, because you cannot create, you can only work with the materials given you. Just as the physician can do no more than interpret and guide Nature (even though by aid of the Greek names so beloved by him he dignifies the processes into "diagnosis" and "prophylactic therapeutics"), so neither can you do more than guide Nature in the natures of the several organisms entrusted to your care. And yet you can indeed create, but it is the conditions or the environment only; for you, have been created dispositions, temperaments, tendencies, inherited and ineradicable. Ineradicable, because these co-called mental attributes depend absolutely upon what is for ever outside the realm of human, volitional, creative

1 An Address delivered to the Education Society of the University, December 1903. This Society is mainly composed of students being trained as teachers.
2 Professor Edgar, Professor of the Theory and Practice of Education, was chairman.
power, namely, protoplasm. You are directed to guide the growth of various immature organisms—more or less differentiated protoplasmic colonies, and that protoplasm is endowed with various attributes or faculties—tendencies and dispositions inherited and transmissible; but, for you, merely the material to work upon, things you can no more alter than you can the properties of the water, air, or earth. The sanguine disposition of one man depends as much on the particular character of the dispositions of the molecules of the protoplasm of his central nervous system, as does the sullen disposition of another man depend on his. The poet is born, not made; so is the wise man, so is the fool—"bray a fool in a mortar," and he is a fool still; he may be an educated fool, a refined fool, a civilised fool, but a fool still. And the wise man (with whom the classical philosophies are so laboriously concerned), he is born just as much as the poet or the fool; you may make him an educated wise man, a refined wise man, a civilised wise man—but you had a latent wise man to begin with, and you have made a better wise man than you started with, because you had a wise man to start with. The utmost you can do, then, is to guide youth; the responsibility is not to misuse the power, but to make the congenital fool a little less foolish, and the congenital wise man a wiser and a happier man. I am not mining matters, for I believe that we do encounter fools, so let us be thankful when they are not knaves as well. We cannot too early in our careers as teachers get this into our heads—that we are what we are, and our pupils are what they are, by reason very largely of what we and they are hereditarily; that our and their dispositions, characters, likes and dislikes, are as much molecular properties of bioplasm, and especially of that of the central nervous system, as the perfume of roses is of the bioplasm of roses, or the stench of old fish is of the bioplasm of fish. The quick boy, the slow boy, the lazy boy, the energetic boy, are what they are because of the particular disposition of the molecules in their living stuff, especially that of their brains; and thus these qualities— quickness, slowness, energy of character—are as dependent on the matter of their bodies, on its invisible biochemical constitution, as the grain of granite is coarser or finer according to the size and grouping of the particles composing it. The quick boy will have a shorter reaction time, a stronger, fuller, faster pulse than the dull boy; physical, physical, physical—almost all is physical. I venture to say we have no idea how much one's whole character, intellectual and moral, depends on the vigour of one's cerebral circulation. All this is being abundantly recognised and acted on by those in charge of asylums, prisons, penitentiaries, etc. Character is daily coming to be regarded as fundamentally a matter of molecules and their inter-relations. Of course we have for long enough known that the hungry man was the angry man, that indigestion was one of the chief causes of irritability of temper,
and that the question whether life was or was not worth living, depended on the liver; but the fact is, that not merely passing moods, but all that we mean by constitution and character, has its physical basis in the molecular organisation of the protoplasm of each one of us.

As a physiologist, I can come to no other conclusion, after not a little thinking over these problems; but if these things are so, their applicability to your profession and to mine is very clear, and it is briefly this,—if character, disposition, power of mind, mental faculties, are attributes of ultimate protoplasmic structure, *i.e.* phenomena depending directly on the physical constitution of the living matter, then the teacher who has to mould the character, weaken or strengthen the disposition, bring out the powers of the mind and direct the faculties, ought to know at least something of the details of the structure of the delicate and complex organism entrusted to his care. I have a right to expect that the watchmaker to whom I entrust my watch knows something about mainsprings and compensating mechanisms, and that the engine-driver to whom I entrust my bodily safety knows a very great deal about the construction of a locomotive, and everything about the signals.

Physiology is the science that tells me what I am, whence I am, and to a certain extent whither I am; it is therefore not only proper, but essential, that you who are to be the guides of the growing youth, and who will largely determine what he shall be, should know something of that science. To be perfectly plain, I hold that every teacher, *i.e.* every State-trained man or woman to whom is to be entrusted the care of the young, should be compelled by law to receive instruction in animal physiology; and in the event of his or her failing to reach a certain standard of excellence in the science, be prevented from proceeding to exercise the profession of a teacher. But you say, We are not going to be gymnastic masters, teachers of swimming, "professors" of dancing or fencing,—what is the meaning of all this talk about physiology, which is the science of *bodily* functions? I reply, Physiology is vastly more than the physiology of the muscular system; and do you suppose you can have thoughts or volitions, moral or immoral acts, apart from a central nervous system which is, after all, at least a part of the body. The less brain, the less thought; the more highly developed the cerebrum, the greater the chance of "high thinking"; do you want strong conceptions and pure thoughts? you must have a strong heart and pure blood. I do not say that thought is conditioned by nothing more than cerebral protoplasm, but cerebral protoplasm is very much more than half of the total conditions. Now, cerebral protoplasm may be in a good or in a bad state, its nutrition may be normal or abnormal, it may be clogged with waste products, it may have a full or a feeble blood supply, it may have been lately over-stimulated, or,
what is more likely, not stimulated enough; and, in addition to all and probably above all, it may have, by inherited molecular disposition, certain obscure, but none the less definitely caused, tendencies, latent possibly, but soon to be patent—tendencies to actions of a certain sort and to thoughts of a certain kind, the totality of which dispositions we call "temperament." Now it is physiology that investigates the central nervous system in its healthy state, discovers the conditions of its healthy functioning, discusses the limits of its possible activity, and indicates certain rules to be followed in fostering its growth in bulk and in acquisitions. The fact that the formation of new cells in the central nervous system ceases before birth has an obvious applicability to educational problems. Of course I do not mean that every teacher is necessarily to teach physiology, far less become a physiologist; but he should know the structure of the delicate physical mechanism entrusted to him, or at least be familiar with the conditions of its most perfect and most vigorous action; and the knowing of this is the knowing of some of the physiology of the central nervous system, such as the signs of nerve-fatigue, heart-fatigue, sensory fatigue, etc. But no one could profitably begin his study of the human organism by taking the nervous system first of all, seeing that it is structurally the highest of all, and functionally, not only the most complicated, but is dependent on almost every other system. Before I understand nerve-impulses, I must know the facts of nutrition, general tissue change, circulation, respiration. In explaining the working of the army, I would not begin by describing the War Office, but rather the constitution of a company or a regiment and their officers. Similarly with the body: the central nervous system rules all other systems, so that we should know what these things are that are governed before we inquire as to what kind of things the governors may be. It is physiology, then, that teaches us what these things are and what these things do; of course, no teacher need be a neurologist, but every teacher should know the conditions of healthy activity of the central nervous system, and that these consist in such humbler things as digestion, absorption, circulation, respiration, and excretion. Humble things, I say, nor is it in any way derogatory to the dignity of the cerebrum to say it, or to know that the brightest and best thoughts are, in not a little measure, the brightest and best, because the stomach, liver, and bowels are working at their best. We are far too apt to forget the humble accessories. What avails a gorgeous banquet, if the potatoes are not boiled, and the salt has been forgotten! If physiology has taught me anything, it has taught me that there is nothing and no function in the whole physical organism which is, in its own place, "common or unclean"; every bodily act is the result of an exquisite co-ordination of otherwise more or less independent activities and neural mechanisms, none the less
exquisite because “humble” and familiar. Familiarity in physiology never breeds contempt, but arouses wonder, admiration, reverence. That man or woman who can be irreverent during the exposition of the glorious adaptation of means to ends in the human eye or ear is lost for ever, dead in the most awful of scientific “trespasses and sins”—the lack of reverence and the incapacity to admire. But not only are these magnificent adaptations admirable; the drawing of a single breath, the throb of a single pulse—familiar and common things if you will—are, if properly understood, fraught with all the richest fruits of philosophy. You remember what Tennyson said was to be taught by the “flower in the crannied wall”: the heart is of more value biologically than many flowers; then—

“Single throb of beating heart,
Man is not more than thou art:
Could I know you in your fullness,
Life had not one hour of dulness.”

Physiology dignifies your profession, and physiology gives certain aspects of it their raison d’être.

But the teacher ought to know physiology for reasons other than those which are the underlying general principles of his profession, reasons of “common life,” as it has been called. For instance, every teacher of a class and every head of a school must understand the physiology of respiration and ventilation; there must not be the mere opening and shutting of windows according to some one’s passing fancy, but we must have it branded into our brains that no healthy life, even for a few moments, is possible without pure air, i.e. oxygen. This conclusion must be reached, not through hearsay on the authority of any man or book, but there must be an auto-branding; every man must be fully convinced in his own mind of the absolute and eternal truth of the statement that life without oxygen is an impossibility, and of course this oxygen is conveyed by the outer air. He must be prepared to go to the stake for this fact, and, having learned it, if necessary by experiment, he must see that he and those whom he teaches live in well-ventilated rooms. Well-ventilated rooms are much rarer than we imagine, and a well-ventilated public building is as rare as the dodo. Of course we have draughts, but a draught is ventilation out of place, and that is very dangerous to health. Why? I wonder how many people could tell me why the chill caused by a draught is so dangerous—for it is dangerous, and to be avoided like the plague. Living matter, in order to do work efficiently and to resist the invasion of the omnipresent micro-organisms, must possess a certain amount of heat—animal heat—i.e. must have a certain temperature, usually higher than that of the environment. Loss of this heat lowers the power of the body to resist micro-organic invasion; in fact, it diminishes all the expressions of vitality of the proto-
plasm. A draught is loss of heat to moving air—the sensation of this is a "chill"; as we lose heat, the powers of resisting the micro-organic invasion are lowered. Now, in all public assemblies there are present many of the disease-producing "germs," so that we are invaded at the moment when least able to resist. We "catch" a common cold or a more definitely nameable disease (e.g. pneumonia), through our loss of heat having caused lowering of the natural bactericidal power of our blood-cells. To understand all this, you must have had some training in physiology, and have seen blood and bacteria, too, under the microscope, else you may late in life exclaim, as did an elderly clergyman on seeing a drop of human blood under the microscope, "Oh, it's exactly like the diagram in Huxley's 'Physiology'!

Now the mention of bacteria or "germs" leads one to speak of the need of instruction in that great modern generalisation, the germ theory of disease, a subject only to be properly apprehended after some study of physiology. The time is surely come when instruction should be early given in the principles underlying vaccination, zymotic infection, prophylactic inoculation, antitoxic injection, and serum therapeutics in general. "Oh, but," you say, "the young people's parents are the proper persons to so instruct them!" Perhaps in an ideal world, but at the present time parents don't know very much about it; the children of to-day are the parents of the future, and you are their teachers; you therefore must be first taught these things. Far more important, these solid facts of biology and micro-biology, than classical mythology and the lists of mediæval murders and murderers with their "dates." The teachers must be got to see that, as following upon the knowledge of pathogenic germs and their products which we possess, the legislative enactments relating to such matters as small-pox and vaccination (only to take one specific case) are not otherwise than imperatively called for. They will, of course, be taught to disentangle the hygienic value of such enactments from any political associations they may have, and to regard it as demographically a matter of moonshine which "party" brought one of them in, so long as it was brought in, and thereafter carried out. Having been previously instructed in physiology, the teacher of the future will understand the etiology of smallpox and the meaning of "immunity conferred by the inoculation of a weakened virus," so that, though he can speak hardly as an expert, still his statements can be made with sufficient authority, as coming from a person not totally ignorant of biology and the practical application of its truths. I hope the time is not far distant when every educated person will be compelled to give assent to, e.g., the four or five following statements:

1. That unvaccinated communities are to-day as liable to the scourge of smallpox as any community in pre-Jennerian times.
2. That vaccination, as practised by Jenner, prevents smallpox becoming epidemic where it occurs sporadically; and, as a matter of incontrovertible historical fact, vaccination has prevented anything like frequent epidemics of smallpox in certain countries.

3. That to refuse to be vaccinated, and go about unvaccinated, or to refuse to allow one's child to be vaccinated, is as culpable a piece of negligence, and is, from a social point of view, as immoral as it would be to walk about with a pound of dynamite in one's pocket.

4. That the present laws on the subject of vaccination are on right lines; and

5. That the man who will not obey them must be forced to leave the country; he ought not to be allowed to reap the benefits accorded to the intelligent citizen while he is a constant and willful menace to the health of the community.

Persons with the requisite biological instruction will give assent to these propositions, even if they are not in the habit of drawing conclusions from facts, while those who have not the requisite biological instruction cannot be admitted to be competent to pass any opinion at all. These considerations are not of merely academic interest, but of vast, vital, personal importance; far more important to the community than discussing the wars of the Greeks or the Persians, or even the Wars of the Roses. I cannot admit that the scientific laity as such, previously uninstructed in these matters of micro-biology, the underlying principles of which are physiological, can be in any sense authorities on subjects involving this special knowledge. But it is just this ignorant, gratuitous criticism that we have so much of to-day, with its outcome of "conscience clauses" and consequent epidemics. Of course I don't want everybody to be a bacteriologist, and I know that we cannot expect every one to be logical; but we can ensure that the person who is not in a position to profit by the work of the specialist, and cannot draw obvious deductions from facts, shall not become a source of social danger either by his opinions or his person. I am afraid that this irresponsible criticism of the laborious results arrived at by men who have spent many years in the pursuit of truth, is greatly on the increase. Of course, the superabundant journalism of the day greatly fosters it. We have far too many people talking and writing, instead of thinking and working; something new and if possible startling must be written by to-morrow morning, and in the midst of superfluous "articles," all sorts of things are discussed without adequate knowledge, space, or patience. Things and people are attacked with a virulence and apparent omniscience that is truly monstrous. In illustration of this, take the case of the criticisms poured out on every one concerned in the late Boer War.

What we want to-day as much as anything is reverence, and the young especially need it—reverence for science and the
teachings of scientific men. Not, of course, superstition and awe bred of ignorance, but that sympathetic reverence for natural knowledge which a careful study of science alone can give us, which at any rate a whole library of the lives of immoral kings, queens, popes, and politicians never can. Along with this irreverence goes cruelty. The boy before he has learnt anything, and the man who knows very little, is usually very cruel; the former pulls the wings off flies and hangs cats up by the tail; the latter promotes cock-fighting and prize-fighting, until he gains some knowledge, and then to his knowledge he adds sympathy, and to his sympathy, reverence. Now it is physiology that teaches me reverence—reverence for that magnificent mechanism, the protoplasmic organism, be it jelly-fish or diplomatist; reverence for the living body, and admiration for it—for every living body, from amoeba to man. There cannot be any "Nil admirari" in science, any approach to it should be shunned as an accursed thing. But in studying physiology we are taught not only scientific reverence, but much of the essence of public and private morality. Is not a very great deal of immorality a want of reverence for the body, or, as some would say, the soul? But while we are waiting for the metaphysicians, theologians, and others to tell us what and where the soul is, we can be very profitably employed in getting to understand something about what people believe to be its beautiful tabernacle. In lieu of more definite information on the subject of the soul, let us get to know what physiology—the science of the shrine—has in store for us. Studies of souls without previous knowledge of bodies, lead not to reverence or even common sense, but to "conscience clauses" and epidemics.

Much of what I have been saying has arisen from our speaking of the necessity of a knowledge of the great germ theory, a scientific generalisation that can rank, in the width of its application to natural phenomena, with the great generalisations associated with the names of Newton, Harvey, Helmholtz, and Darwin; but, obviously, to understand "about germs," a previous knowledge of physiology is needed. Just for a moment consider the different subjects upon which it has shed valuable light—the healing of wounds, modern surgery practically dating from its promulgation; the vast subjects of etiology, pathology, and therapeutics of zymotic diseases; the whole chemistry of dairy farming and the artificial preservation of food stuffs; the chemistry of putrefaction, of the disposal of sewage, of the nitrification of soils and of manures; and the chemistry of brewing—in fact, the whole of the understanding of fermentation, not to speak of certain subjects in pure science, such as the chromogenic powers of bacteria, their polymorphism, the bactericidal powers of light, and certain purely theoretical considerations, such as the size of the molecules of protoplasm and of albumin. To know nothing of these things is to be dead to the modern half of the science of the living, and is in
science comparable to the state of the man who knows no dramas since Shakespeare's, no music since Handel's, no painting since Raphael's. The understanding at the present day of the chemistry of fermentation is just as important in after-life, and is related to as many vital questions of huge import, as understanding the subtleties underlying the ground for the divorce of Catherine of Aragon. It would almost seem as if we were afraid of keeping abreast of the times, afraid of realising the extent to which we are surrounded by impalpable but none the less implacable foes—some of "the powers of the air" made manifest by science. But a knowledge of physiology must come first, and I do not see that it is coming even to those who shall be teachers to-morrow. The late Professor Huxley declared that he had been "a bore" on the subject of the importance of a general knowledge of physiology; but I cannot see that we are to-day one whit better in this respect than thirty years ago when he spoke. Physiology actually does not form one of the very many subjects which make up the group for the degree of M.A.—and that after the deliberations of the men of "light and leading" who composed the Scottish Universities Commission. Thus far we have said hardly anything about what is supposed to be the main duty of a teacher—the training of the mind, because I at any rate hold, paradoxical as it may seem, that the needs of the body must be well looked after before those of the mind be in any way specifically catered for. You cannot expect to get delicate results from a coarsely made machine, fine reliable results from a thing put together haphazard.

One of the most important body considerations is athletic exercises, and many men certainly imagine that taking exercise is the one thing in life. In this matter of school athletics, if anywhere, physiology must be heard. The gist of the subject, from the physiological side, is, that of course a certain amount of muscular activity taken in the open air, and if possible in the sunshine, is absolutely necessary for the maintenance of the highest health. But here, if anywhere, must there be no hard-and-fast rules, e.g., as to the number of hours to be given to athletics, for what may be an excessive amount for one boy or girl may not be nearly enough for another. The amount of muscular exertion which the youth possessed of well-developed muscles and a strong heart can put forth is too much for the youth with poorly developed muscles and a weak heart. A knowledge of physiology is required here to guide the teacher in deciding each case on its own merits. It does not follow that all boys of the same age should take the same amount of exercise, or that the same form of athletics is suitable for all alike; it is manifestly not so. We must have no cast-iron rules about running so many times round the house. A can run thirty times round the house, B cannot do so three times with impunity.
the last fifteen years we have heard a great deal about athletics and gymnastics for girls, and their introduction into the ordinary school life of the girl is a most enlightened innovation; but I am quite sure that in their violent out-of-door games, girls require close supervision. Most of them, those of high spirits, have a natural tendency to overdo their games, and for some of them, in the actively growing period, I consider hockey a dangerous game. To judge of these things, not of course as an expert, but as one who knows when to call in the doctor and when not, the teacher must have an understanding of the main facts of the circulation of the blood. He should know that muscular contraction, by pressure on veins, is one of the most important factors in determining the return of blood—impure blood—to the heart, so that it is perfectly easy to overload the heart through muscular activity alone. I am not speaking about the onset of fatigue at all, important as muscular and neural fatigue are, but about a condition, overloaded heart, which, as most people know, can be brought on in a very short time after the commencement of the exercise. Now it not infrequently happens in young people of both sexes, that we have a condition of powerful muscles and a weak heart, precisely the kind of case requiring close supervision in the matter of bodily exertion, for it is clear that in proportion as the muscles are powerful, the heart can be the more quickly and effectually overloaded. To the eye of the layman, however, this class of youth would be deemed quite fitted for "any amount" of running, jumping, swimming, and gymnastics, whereas to the educated eye the conditions here that might lead to permanently dilated heart are all present. I am certain that many young people of both sexes have in this way gravely damaged their hearts. There must then be no rules as of the Medes and Persians about exercise for the young, growing, and therefore easily injured frame; both the quantity and the kind should be left an open question for each case in turn. If it is objected that the giving full weight to these considerations would seriously interfere with the time-table of the classes, I reply—so much the worse for the time-table; are ye not of more value than many time-tables? For, after all, what do we want? Not a few geniuses, or many fact-crammed intelligences, but bodies and minds of a so-called "all-round" order, thoroughly furnished for the coming struggle for existence. For I suppose that, after all, the "whole duty" of the teacher is to impart the principles that make for success in the lives of his pupils; and I suppose we all believe that success by no means always comes to the most brilliant, but rather to the man of average ability with infinite powers of taking trouble and a good digestion. I am not joking; the condition of the circulation and the condition of the digestion together make up about nine-tenths of temper and disposition—important factors in success.
Must we always be taking exercise when we are not doing brain work? By no means. There are some educationalists who seem to believe that outdoor exercise is the cure for every ill that youthful flesh is heir to, and they seem to assume that recreation is synonymous with exercise. I would like to explain to these persons what the physiology of rest means. There are times and circumstances when it is not only no recreation to take exercise, but positively harmful to do so. We are apt to forget that mental effort involves fatigue; it is not always wise to add to it muscular fatigue. Nature's indications may here be followed. After that prolonged fixity of the attention, which is, or should be, the condition of the mind in "learning lessons" at school,—for, of course, when mental work is to be done, it should be done with the highest degree of concentration of the attention,—there is produced a distinct fatigue of the central nervous system. Nature would now indicate a period of repose, preferably in the open air,—if not of complete rest, then of such muscular exercise as cannot possibly involve fatigue. Those who feel fit for exercise after mental work may take it; but anyone who feels disinclined for it should not only not be forced to take it, but should be examined for possible defects of constitution. Young people vary enormously in their capacities for sustained effort and in their susceptibilities to fatigue. Those who seem to be very easily tired, or whose attention it is very difficult to fix, for even a short time, will be found on careful examination to be suffering from some disability of circulation, e.g. anæmia, or from an incapacity of nerves, neurasthenia. I tremble when I hear the relatives of an anæmic or neurasthenic young person tell him or her to "go for a smart walk in the wind"; what that person wants, young though he or she be, is rest, quiet, and good feeding; but, above all, rest. No one can work till he has a store of oxygen already accumulated. It is most fatal to go upon the assumption that because all those at school are young, they are also robust. It is no doubt sad that some young people are anything but strong—but many things that are facts are also sad. The not perceiving of this fact has made of some school-boys, and more school-girls, life-long invalids. I want to emphasize the physical responsibility of the schoolmaster, mistress, or tutor. (The very sad case of Prince Rudolph of Austria is an illustration of what I mean. A cast-iron régime, involving getting up too early, and working too late and too hard, created a condition of permanent nervous irritability.) Now, it would be well to know the physiology of fatigue, its signs and physical concomitants; and also to know that protoplasm never works continuously. We speak of the constantly beating heart; but it may interest some of you to know that, in the course of the twenty-four hours, the heart actually rests no less than nine hours. So it is with all the more active tissues; their times of activity alternate with periods of repose; and the law of the tissues should be the
law of the organism which they constitute. The physiology of rest is not sufficiently known—the value of resting not sufficiently appreciated. Work as hard as you can while you have to work, and rest as often as you possibly can in the intervals. Do you know the value of lying down to rest, for the heart has far less to do in the recumbent than in the upright posture?

This and much more we learn from a study of the circulation—upon which, you see, we are constantly thrown back. Now let us come to the class itself, and to the intensely practical question, Shall it sit or stand to "learn its lessons"?—the answer is most emphatically, Sit. The physiologist knows how the upright posture involves fatigue, and that this fatigue is not merely muscular but neural as well, for the maintenance of the erect posture is a neuro-muscular act. It involves a whole series of muscular adjustments directed to the continuous task of preventing the various segments of the body from falling backward or forward of the transverse vertical plane—a series of adjustments that finds expression in a series of to-and-fro and side-to-side oscillations which can, by appropriate device, be graphically recorded. In plain language, we cannot stand still; the most obedient child, the most conscientious sentry at "Attention," the most deferential stranger commanded to "Halt," never yet did stand still. These muscular adjustments in the earlier stages, before the posture becomes monotonous or painful, are carried out sub-consciously; they nevertheless involve fatigue, apparent in time. The physiology of fatigue has not yet by any means been sufficiently attended to. I venture to say that after a class has been standing up for some little time, you will find the vivâ voce replies more inaccurate and more slowly given than after the same class has been seated for an equal length of time. Although we have much to learn, our study of fatigue teaches us that the physical part of fatigue is the discharge of effete material which clogs up, as it were, the molecular wheels of the living machine. Fatigue is the temporary functional incapacity due to the accumulation of katabolites, whereas exhaustion is the actual using up of the living material beyond the limits of repair or reconstruction. This is the technical import of the terms; exhaustion means irreparable structural damage through excessive activity. Now, surely all teachers should have some knowledge of what neural fatigue means, of what are the signs of fatigue of the sensory, nervous, and locomotor systems. This is surely necessary, in order that we may direct aright the quality and quantity of the output of energy in their relations to age. Teachers are in the main concerned with immature, developing organisms, and it is precisely these in which the activity limits should be carefully looked to. I am rather inclined to think that we begin to "educate" the young brain too soon and leave off too soon.

We have too many cases of very bright young children who in
a year or two do not fulfil the very good promise that they have given. The reason for this is, that we gave the developing brain far too much to do while it was still structurally imperfect, overloaded it with impulses from without, and, as a consequence, with an amount of fatigue products much too great for its delicate, partly formed, unfolding substance. In other words, its retaining power was not equal to its affectability; affectability first appears—the power of receiving impressions—and then later, and, as a result of previous judicious activity, appears receptivity, or the power of retaining impressions, of using them, of synthetising them. A high degree of affectability is often mistaken for cleverness—and such, if you wish, you may call it; but something more is needed in the central nervous system as the underlying principle for ability. The country can do with a few geniuses as its ornaments, but its power resides in its fully-developed but not over-stimulated brains. If you could only realise that you are dealing with as real an organ as is the surgeon when he incises the liver or cuts through a muscle. The eye of the physiologically trained teacher must know the limits of the safe exercise of functions the most various—the activity of eye and ear, and of attention generally, of the heart, and of the other muscles. This must follow, if we believe that education is what Professor Edgar so well calls it—the scientific directing of growth. But how can you direct what you do not understand? You say, "Our business is to communicate ideas." Good and well, if the soil is all right; but you must see to it that it is at least productive. There is little use in sowing good seed in anaemic, depressed, over-stimulated, or fatigued brains. It is a throwing of intellectual pearls before protoplasmic swine. "But," you may say, "all this physical preparation should be done by the parents." Let that be granted; at present the parents do not know how to do it. I speak for the future; it is you who are to train the parents of the future in their duty.

That I am not laying too much stress on the physical aspect, is evident from the revelations of the late Commission on Physical Education in Schools and as to the State of Recruits for the Army. Sir Norman Lockyer, in his presidential address to the British Association this year, cried aloud for more "brain power." All the universities in the world cannot confer brain power upon brains physically unfit to be exercised. So-called "brain power" is a function of brain tissue; and the constitution of brain tissue is a question of nourishment and of the endowment of brain tissue, i.e. of inheritance, and of action of environment, which latter includes education.

The teacher is then, in the first place, to be the director of physical exercise, and may safely begin by prescribing, for every one, simple breathing exercises—the full inspiratory expansion of the chest. Imperfect pulmonary ventilation is the cause of much
lung disease. I know of at least one school where breathing exercises are regularly carried out. The teacher would have to settle a question which arises at the very beginning of the day, namely, Shall classes be held before breakfast? The answer of the physiologist is emphatically "No." In a school there ought to be quite enough to be done in the way of bath-taking and dressing to occupy the time before breakfast without entering upon studies. Work done at this time is done in a state of hunger, and often before the rooms, in winter, can be heated, and is certain to be regarded by the pupil as decidedly unpleasant. This is a most unfortunate concomitant of any kind of mental work, and certainly tends to make it of poor quality. We all know about Sir Walter Scott, Trollope, and others, who did good mental work before breakfast, and about Sir Isaac Newton and Edison working all night at a problem; but the cases of a few great men cannot be the guiding rules for school children. What a full-grown man, who is intensely interested in the work in hand, may do, is no example for "lesser lights." But thus it is that some school-hours are made positively purgatorial, when, e.g., young girls are knocked up in winter, and, without food, made to play on the piano before breakfast. This, and this sort of thing, is far from right. Teach your classes, especially of young people, in bright, warm, sunny rooms; make lesson-time as physically pleasant as possible, and even the quality of the work will improve. Unquestionably the supreme concern of the teacher is the superintending of the functional acquirements of the brain, and this is attained by the opening up of as many new paths as possible into and within the various sensory centres in the cerebrum. But this inevitably means the opening up of the lines of communication (by the multitudinous commissural fibres) between the sensory and the motor centres. This is what education means—inter-cerebral co-ordinations and the establishment of sensori-motor paths.

The first process in all this is the training of the sense-organs, the sending in of impulses through these great avenues between the outer world and the inner man: pour in impulses, judiciously of course, but pour them in through all the sense-organs. Give eyes, ears, taste, smell, and touch all something to receive; let hands be trained along with eyes and the important muscular sense trained with the rest. Education is, first, sensorial reception; then cerebral perception; lastly, motorial execution; and the corresponding functional endowment of the centres involves and causes the actual histological differentiation of the cells of these centres. This training of sense-organs is practised in the earlier years in the Kindergarten system; but this gives way too soon, and just when the intelligence is expanding, to a system of a totally different order—book-learning. What is wanted is a still wider acquaintance with nature—with matter and energy as well as with all accessible forms of life—everything available for sensory
knowledge at first-hand. No doubt much has been done in the way of teaching zoology and botany as well as chemistry and physics, and a little, a very little, physiology, in many schools; it is all on right lines, and needs encouragement and extension. Even the small amount of real knowledge of this kind derived directly from nature—giving an insight into the properties of matter, the correlations of energy, the structure of the flowers and trees, the habits of insects, birds, and beasts, the meaning of sunset colours, of the rainbow, of the tides, winds, meteors, and eclipses, is more enduring and more valuable for the business of life than very much philological and purely antiquarian lore about dead languages and dead nations—intellectual luxuries rather than necessities.

Of course this knowledge-by-reception should be acquired pari passu with the knowledge-by-execution; the training of hand, i.e. of muscular sense, cannot be commenced too early. Now I know of no hand-training equal to that afforded by the manipulations of practical physiology. Show me a person who considers himself neat-handed, and I will disillusionise him in half an hour. This is the training for the teachers themselves, for they acquire thereby not only knowledge of the living matter at first hand, but they are taught steadiness in muscular adjustments, delicacy of perception of the muscular sense, and the necessity for promptitude in action. There is almost no other science which trains so many faculties at once—power of observation, the drawing of inferences, criticism of results in light of theoretical considerations, the avoiding of numberless experimental pitfalls, creative power and resource in emergency, not to speak of trials of physical endurance, of patience and of temper. I frequently point out to my students that physiology trains far more than one's intellect. But all this means training of the nervous system, because it means sensory knowledge correlated to subsequent muscular adjustments. Knowledge of the physiology of the central nervous system would never allow a man, for instance, to read too much before going in for an examination. He would know that the facts poured in—fact-bearing impulses poured into his central nervous system until neural fatigue sets in—can never be properly assimilated or reproduced, i.e. are of very little value. A fatigued brain is a non-receptive brain, and if a brain is non-receptive, while you are instructing it, it cannot reproduce what it has not in reality received. It is, after all, very largely a question of physical factors. The brain-substance must have plenty oxygen, which it can only get through much pure blood. It may be humiliating to the great philosopher to be told that his finest thoughts are largely conditioned by the purity of his blood, and that by the state of his intestines and kidneys; but it is true for all that. Some students know that the brain works best just after moderate exercise, which means that its circulation is then more than
usually vigorous—and so we are thrown back once more on the circulation. But another consideration would not let a person overwork himself or herself before an ordeal of any kind, namely, the fact that the more protoplasm has done for a certain time in the immediate past, the less it can do for a time in the future. Work previously done means the diminished capacity for work in the immediate future. This is nothing new—the tired man cannot do very much. Protoplasm that has rested and is fed is in a state called by the Germans “Leistungsfähigkeit,” or capacity for (future) activity, as we would say. The principle is nothing new—Rest well to work well.

A study of physiology is of value in sweeping away superstition, first from the mind of the teacher and then from the taught. While I suppose no one now believes that the female skeleton at the present time suffers from a deficiency of a rib on one side, as an hereditary modification in consequence of the formation of Eve out of Adam (as I was taught), yet a very large number of people, it would appear, believe in what they call “faith-healing.” Now, no one believes as firmly as I do in the power of mental states over bodily, but to admit the contentions and even so-called “facts” of the “faith-healers,” is to place one’s self intellectually on an equality with the most superstitious of believers in the miraculous in the darkest ages of the Church of Rome.

There is still much superstition as to certain questions of heredity, descent, and allied subjects. Some people believe that Mr. Gladstone lived to be over eighty, because he chewed each mouthful twenty-two times. Physiology teaches us that the greatest possible caution is necessary in drawing inferences from even the best authenticated facts; it introduces us to so many factors and modifying conditions entering into even the simplest functional problem, that it constitutes an intellectual training of unparalleled value. I could name several problems in physiology fitted to tax all the critical acumen that can be brought to bear upon them by highly trained biologists. A knowledge of physiology would quite dispel the idea that the physical organism of man is perfect, in the sense that his mental powers may be considered perfect, as expressed in Shakespeare’s famous lines in Hamlet, beginning, “What a piece of work is man, how noble in reason, how infinite in faculty . . . in apprehension how like a god, the beauty of the world, the paragon of animals.” While most reverently admiring the exquisite correlation of functions and means to ends in the animal organism, we can easily point out a large number of “defects.” Beginning with the obvious facts of facial asymmetry (said to be very marked in criminals), we can pass on to organs, and catalogue a number of so-called defects, even in such an exquisite mechanism as the eye—opacities in lens and vitreous, fluorescence of media, peripheral colour blindness, and so on—and could conclude by remarking that even our
general metabolism is often greatly at fault. A large number of people are kept all their days on the verge of attacks of acute gout, by a perverted nitrogenous metabolism giving rise to uric acid and allied substances, either too copiously for elimination, or in a form not amenable to excretion. It is not generally known that, even in normal digestion, compounds actively poisonous, were they to get into the blood, are formed. Normally they are rendered non-toxic in absorption, but when "something goes wrong" with absorption they soon make themselves unpleasantly felt in the familiar sick-headache, etc., for auto-intoxication is not by any means so remote a contingency as you may think.

The fully equipped teacher of the future will know something of the composition of foods, their nourishing values, the principles of cooking and their application to digestion, and the relative cost of food-stuffs. It has been well said, there is probably no nation so fond of good cooking as the English, and none with fewer good cooks. It is notorious what bad caterers the most of the poorer classes are, how vast is the kitchen waste through bad buying and bad preparation of food. Dietetics and dietetic statistics should form part of the instruction for all teachers. It is just as important to be able to prepare porridge or coffee as it is to play the piano, and it is oftener asked for. Is there any nation that drinks worse coffee than we do? Punch's picture was founded on fact—"If this is tea, I wish coffee; if this is coffee, I wish tea."

We lastly come to what may be regarded from a certain point of view as, after all, the most important of the teacher's responsibilities, I mean the teaching of the young to practise inhibition. As consciously exerted, this is a purely cerebral function, and one of the highest, if lateness of appearance in cerebral functions be a measure of functional eminence. Inhibition is a technical term for restraint, and I fancy that we would all admit that restraints do not come naturally, but are rather late and laboriously evolved productions. The young child, like the young animal, is a bundle of reflexes, and the early training of each of them is a training in restraining—in practising restraint. The spinal cord is a great linear series of reflex centres, of which the actually lowest in space is also the lowest psychologically. Even these reflex centres of the more lowly animal functions are not mutually independent, but any one of the series inhibits the activity of the one below and is in turn itself inhibited by the one above it. As the child and the animal grow up, they learn to voluntarily inhibit these lower reflexes (concerned with abdominal and pelvic viscera). That this is carried out exclusively by the brain, is proved experimentally in "the spinal animal," and in man in cases of spinal disease, in which cases volitional restraints are impossible: in the former case the seat of the inhibitions has been destroyed, in the latter the paths of conduction of them to lower spinal centres
have been cut through. This mutual-restraining action between various levels of the central nervous system is, then, the physiological basis of inhibition. The lessons of inhibition are sometimes learned through painful sensory experiences. The sight of the fire is sufficient, a second time, to arouse in the burnt child an inhibition of the movements caused by the desire to touch the glowing coals, and the stinging nettle may for a time be the source of many inhibitions of desires to pluck harmless as well as harmful plants. A child may have cried so long for the moon that it received a whipping, the recollection of which is sufficient to inhibit its desire next evening for all bright objects.

There may, then, be said to exist an acquired antagonism in the nervous system between its higher and its lower regions—no doubt the physical basis of what is called in religious language, "the conflict of the higher and lower natures." As the individual is the more trained, restrained, educated, cultured, these inhibitions are more numerous, better developed, and more easily called forth; and that social state is the highest, or at least the most complicated, in which the greatest number of restraints to individual freedom of action exist—restraints, of course, in the interest of the common good. In the simple village you may keep poultry and other animals, have a dunghill close to your neighbour's door, practise on a musical instrument till two in the morning, and so on; but in the more complicated urban community, poultry and dunghills are nuisances under the Public Health Acts, and musical instruments equally so by common consent, not to speak of police bye-laws.

This restraining, then, of the freedom of the individual in the interest of the many, is brought about through his being constrained to practise inhibition; and all individuals do not learn it equally quickly. I want my way, you yours; but we soon find that we can neither of us have it wholly, and so we inhibit much that we desire; we mutually adjust ourselves, within limits, to conform to the prevailing "tone," and to that extent are good citizens. But the man who will inhibit almost nothing, who will have all he wishes, without regard to you or me or his neighbour, is to this extent anti-social. He has not learnt inhibition; he may be a mere harmless "crank" or faddist; he may be a most dangerous criminal. Lack of inhibition is the physiological basis of a very great deal of crime: the so-called "Hooliganism" of large cities is a case in point—bands of young men wandering about at large unrestrainedly, smashing everything, including heads, that they encounter; they have not learned inhibition. No matter how much a man learns, if he has not learned inhibition, his education is woefully incomplete. The applicability of this physiological function of the cerebrum, namely, inhibition, to the upbuilding of character is obvious. "The habit of doing that which you do not care about, when you would much rather be
doing something else, is invaluable," wrote Professor Huxley. Inhibition is the alpha and omega of education: it is the alpha, for it is the very essence of morals, private and public. Just as love is the fulfilling of the law, so is inhibition the fulfilling of the condition which makes harmony and a co-ordinated whole out of the otherwise anarchic activities of the nervous system. "Even if I give my body to be burned, and have not" inhibition, "it profiteth me," physiologically speaking, "nothing." An educational training that does not develop inhibitory powers is worse than no training; then, indeed, would we have "a nation of educated devils." He would be a bold man who would deny that modern life does not afford plenty opportunities for the exercising of this power. Inhibition is as much of the very web and woof of physiological psychology as is volition; in fact, they are not only not different processes, but in many instances identical, i.e., there is volition or will to act, and there is the will not to act, which is inhibition. There is, then, volitional inhibition—the active will to restrain action begun or to prevent incipient action from becoming actual. The physiology of this is, that the spinal centres for muscles must receive from the cerebrum, through special paths, impulses of a specific order, namely, those tending to diminish the excitability of the lower centres. The precise mechanism of this restraint is still not wholly known, it may be an interference phenomenon.

We cannot, I need not say, inhibit emotion. We can no more inhibit the uprising of an emotion, a desire, than we can inhibit the rising of the sun. We can keep out of his rays, and we can similarly walk off from the emotion-producing scene; but there is no mechanism in the central nervous system for preventing the development of pleasure on viewing a fine landscape, or of pain on touching a red-hot coal. All that we can inhibit are the incipient motorial impulses to action; but it is a very great deal, and life teems with opportunities for the restraint of incipient action and tendencies to action. This is the physiology of the withstanding of temptation. The physiological statement of the neural processes may be new, but the necessity for inhibition is as old as the dawning of religion, and of the first strivings towards higher and better things than those of unrestrained animal nature. Our manifold temptations are just so many occasions of restraint; and it is as true to-night as it was all those centuries ago when it was written, that "he that ruleth his spirit is better than he that taketh a city."