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*PHYSIOLOGY IN THE SCHOOLS.**

THAT some knowledge of physiology and hygiene should form a part of the education of every human being will, I think, be granted by every one who believes that wisdom is safer than ignorance, that ignorance is not innocence, and that health and manly and womanly vigor are better than nerveless helplessness, and lastly that a knowledge of what the Creator pronounced 'very good' is worthy the contemplation and thought of man. It is not necessary, however, to enter into an extended defense or advocacy of physiology and hygiene in the schools; they are there already by the sanction of the people and their representatives in the State Legislature, and hence the real question upon which thought and discussion should be directed is: How can this study be made to yield the best results of which it is capable? The question is apparently easily answered by saying: Put good text-books in the pupils' hands, and supply capable teachers and ample time and facilities. While such an answer may seem sufficient, it is in the present state of educational progress only hollow sound. What is really needed is a discussion of what makes a good text-book, how earnest men and women may become capable teachers, and how facilities, often inadequate, and time mostly too limited, may be best utilized.

* A paper presented at the Thirty-fourth University Convocation of the State of New York, June 24, 1896.

As to the text-books—and there are many of them of various grades of excellence—none seem to me to come up to the standard which should be striven after. The defects are due either to an author's imperfect knowledge of modern physiology or to unfamiliarity with the actual needs of the school room. I believe no truly great text-book for school, college or university can be created out of hand. It must be an evolution, a growth in its natural environment, the school room or laboratory where the pupils can help the teacher by their questions and difficulties. The atmosphere must be one of freedom for learner and teacher. Books written by so-called 'experts,' under the *supervision* of the scientific department of a temperance organization, may, it is admitted, make the subject 'very exciting and entertaining;' that is not what is here advocated, however, but a book by a teacher who, on the one hand, is truly an expert in the grade of schools where the book is to be used, and on the other, the possessor of a knowledge of physiology at first hand; that is, he must have a knowledge that is recognized as expert by the physiologists of the world, then he must write under the *supervision of* his own conscience, not that of an organization.

It is a truism which cannot be repeated too often or too emphatically that one cannot teach what he himself does not know. Therefore, for the teacher of physiology the first requisite is knowledge. Knowledge from books and of books and monographs, but greater than all book learning is knowledge at first hand from nature herself. Such knowledge has the precious quality of being alive, of being the leaven to vitalize the whole lump of knowledge obtained from books, and it makes teaching an inspiration to both teacher and pupil. Such information can only be acquired by the expenditure of considerable time and money. A six weeks' course will hardly accomplish it, although I hasten to add that a term at a university summer school or at a sea-side laboratory where the instruction is given by original investigators will give an uplift and inspiration to an earnest teacher that will be of inestimable value.

But, given the suitable text-book and the capable teacher, *what* shall be taught and *how* shall it be taught? The question of instruction upon the effects of alcohol and other narcotics need take but a sentence, for the subject has been most ably treated by President Jordan and discussed by our Superintendent of Public Instruction, Charles R. Skinner, and others. If I rightly understand them, my view corresponds with theirs and with those of my honored teacher, Prof. Burt G. Wilder, who is to discuss this paper. It is, in a word, to tell the truth, to present fairly both sides of the question, so that when the pupils use their own eyes and put the statements to the test of experience, as most of them surely will, they may feel, as well as know theoretically, that the statements made are true, and the teacher's earnest counsel is reasonable and not merely lurid sentiment.

Another problem will confront the teacher, prepared as indicated above; that is the experimentation upon living animals for the purpose of instruction in the schools. If he has the knowledge requisite he will know that, excepting a few facts, all which is known of physiology and hygiene has been acquired by experimenting upon living animals or living human beings. If one stops for a moment to reflect, physiology deals with the functions or activities of living organisms; it has to do with the living, not with the dead. For example, how shall one know whether a plant is good for food, whether it is medical or poisonous? Of two white crystalline substances, like chlorid of sodium (common salt) and chlorid of mercury (corrosive sublimate), how is one to know that one is almost indispensable for

health and well being in both man and animals, while the other is deadly to both and also to plants? Certainly the desired information cannot be gained by the chemist's test tube or by application to a dead animal. How are the splendid results of the modern physiological psychology being attained? Not by dissecting the dead, but by experimentation upon the living.

Shall our schools then become the 'chambers of horrors' described by the anti-vivisectionists? Heaven forbid! The fundamental facts of physiology, those most intelligible and useful for the pupils in the schools, can be demonstrated for them and by them without the infliction of pain or even discomfort; and most of them can best be performed by the pupil upon himself. Let us take a few examples: Every child knows that there is feeling, as he calls it, in the skin; he also knows the sensation of cold. But he, and indeed most grown people, do not know that the tactile sense does not reside in every part of the skin, and so of the temperature sense. If some object like the rounded end of a lead pencil or a bit of steel be drawn carefully over the skin, say upon the back of the hand, it will be felt simply as an object over the tactile areas, while over the temperature areas there will be a sensation of cold. Then how easy it is to give the real physiology of muscle by having each pupil perform some definite movements of the arms. If the muscles are felt during these movements, especially if some force is exerted, as in lifting a weight, the changes in the form and consistency of the muscles can be easily determined. It will also probably be a revelation to the pupil to find that in raising the arm, for example, the muscles around the shoulder and at the elbow, which by themselves would tend to lower the arm or draw it outward or inward, also contract. After such an experiment it will not be difficult for the pupil to understand that, for the steady and definite movements of parts where the joints give considerable freedom, it is necessary that there should also be a moderate contraction of antagonistic or opposing muscles which by themselves would cause movements in other directions; that is, he will gain, by such a simple experiment, the ground idea of coordination.

Perhaps none of the experiments that can be performed are of more practical utility than some simple ones in digestion. It is now very easy to obtain from the pharmacies the ferment of the stomach or of the pancreas. With these ferments and a glass vessel the pupils can see for themselves the solvent action on various forms of food. They can see that finely divided food is more quickly dissolved than large masses, and hence one of the principal advantages of thorough mastication. So if the ferment of the saliva or pancreas were mixed with raw starch and with cooked starch it could be seen, with a distinctness never to be forgotten, that fire is a powerful ally of the human digestive organs. These experiments are also instructive because the processes are practically identical with those going on in the living body, and thus illustrate the side of physiology that may be demonstrated without experimenting on a living organism.

The circulation of the blood is a fact of such fundamental importance and so interesting in itself that every student ought to have the privilege of viewing it under a microscope. This can be very easily shown in the web of a frog's foot or in the external gills of a water salamander like the Necturus. If a little ether is put in the water containing the animal it will soon become anæsthetized without interfering with the circulation. The ether will render the perfectly painless observation successful without even arousing the apprehensions of the animal, which soon revives when placed again in fresh water, and appears as happy

as if nothing had occurred. The experiment will also illustrate in a striking manner the effect of anæsthetics on all living beings. A very far-reaching lesson may be given by having each pupil perform some of the simpler experiments showing the illusions of the senses; these are so graphic that the dullest cannot fail to appreciate the fact that the only safe way is to look on all sides, to verify appearances by applying as many tests as possible—in short, to appreciate the *scientific method* which is so tersely expressed in the words of Scripture, "Prove all things; hold fast that which is good."

So far nothing has been said about anatomy. What place shall it have in a course upon Physiology? Undoubtedly it is a very great help in the study of function to have a good knowledge of the structures performing the various functions; but it seems to me that in many books, and in some courses in physiology, anatomy is so preponderant that the physiology is too much lost sight of—that is, the mechanism is exalted above its achievements. Only the grossest functions of the organs, like the supportive action of the bones, can be deduced from the anatomy alone; yet it is certainly the fact that, after the physiology has been once determined by experiments upon living beings, one can often see how admirably the structure of an organ is correlated with the performance of its function. For example, the small intestine with its millions of villi projecting like so many rootlets into the digested food seems from its very structure destined for absorption.

On the other hand, if one studied never so profoundly the structure of the salivary glands and the pancreas he would never know that they produce digestive liquids without experiment, and much less would he know that the one is so limited in its power (saliva) and the other so unlimited and powerful as a digester. So I think the microscopic structure or histology is liable to be made too much of in elementary books and teaching. But, for a few points, the microscope is truly a revealer; *e. g.*, the mystery of the current by which the air passages are swept clean of dust and other particles is simplified by microscopic observation which shows the tireless multitude of cilia with their ceaseless waving. The fact is not to be forgotton, however, that even in this case only the minute agents and their method of work have been found. *Why* they work is as great a mystery as ever. So also in the study of the circulation of the blood under the microscope one can see how closely every living element is surrounded by the blood capillaries, and how ceaselessly the blood corpuscles and the plasma move along, to be followed by a never-ending fresh supply.

The purpose of this paper has not been unduly to criticise, but to throw out what I hope will prove to be a few helpful suggestions. That the efforts of the teachers of this State are earnest and devoted is thoroughly believed. That the pupils they instruct are not all acquainted with sufficient anatomy and the fundamental principles of physiology is also known by the examinations for entrance in the University in which I have the honor to teach. From carefully compiled statistics obtained during the last few years it is found, however, that the pupils who have studied physiology something in the way indicated above have been far more successful than those who have merely studied the books.*

* Facts concerning entrance examinations in physiology at Cornell University: The great majority of students enter in physiology with the other studies, from Regents' diplomas or from graduation at accredited schools.

From the reports of the President and Dean it was seen that about one in sixteen so entering could not remain in the University on account of defective scholarship, while of those taking entrance examinations

If in closing I may briefly epitomize, it seems to me, that the best results may be obtained in physiologic instruction in the schools as follows:

1. Text-books written by able teachers who know the subject at first hand should be provided.

2. The fact should be emphasized that physiology is very real, and that every one may demonstrate upon himself many of the most striking and fundamental phenomena; for example, how quickly will the pupil see that it is not necessary to go to the teacher or to the book to find out the number of heart-beats and respirations per minute, and that both are greatly accelerated by exercise or excitement.

3. Anatomy should not overshadow physiology, but nice structural adaptations whereby specific functions are performed may be pointed out and worked upon with great advantage; for example, the valves in the heart, the veins and lymphatics, the forms of the joints, etc. Such knowledge is interesting and would aid all. Perhaps also it might arouse some slumbering genius whose future efforts would reveal adaptations now hidden.

4. The teacher should inspire his pupils with respect for the human body and its powers, and with due sympathy for all living things. Lastly, he should impress upon them with solemn earnestness the fact that their physical and moral health is largely in their own hands, and that the physical and moral laws of their being are inexorable.

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at the University one in eight was dropped, showing that the more poorly prepared were those who came for examinations including physiology. Physiology papers of 195 of the latter class have been looked over with reference to determining the quality and kind of preparation made, as taken from answers to questions.

The average standing of the 195 was.....53%
The average standing of those having dissection and drawing.....59%
The average standing of those having nothing but books.....47%
The average standing of those self-prepared.....59%
The average standing of those having previous college training.....66%

DISCUSSION OF PROF. GAGE'S PAPER ON PHYSIOLOGY IN THE SCHOOLS.

IT is fitting that the address on physiologic instruction should be given by a Cornell professor. For, in 1868, at the suggestion of the first president of that institution (the Hon. Andrew D. White) the entire Freshman class attended a course on physiology and hygiene during the first term; the examination questions were such as were asked in medical schools at that time, and diagrams were required of both macroscopic and microscopic structures. The choice of the speaker was equally happy; for the year of his graduation, 1877, was memorable in the annals of Cornell, in that then first physiology became a requirement for admission. Furthermore, Prof. Gage is a master in the elucidation of the fine anatomy of animal tissues which aids so materially the comprehension of function, and his address last summer as President of the American Microscopical Society, 'A Plea for Physiologic Histology,'* well merits mention in this connection.

If I commence with an emphatic corroboration of his complaint as to the inadequacy of existing text-books, it is because no other want has been more constantly and keenly felt by me during the twenty-eight years in which I have delivered 40 courses of lectures upon physiology (one-fourth of them in medical schools), and have addressed upon the subject more than 4,000 individuals.

From the nature of the case a text-book can never be *complete*. But the other four of what I call the five C's may surely be

*SCIENCE, August 23, 1895.