knife-edge by means of which the recording lever is set in motion is fixed, can be varied in length; and this makes it possible to vary the magnifying power of the lever, because the distance of the knife-edge from its axle can be changed. Such an addition has always been a desideratum, even in the wrist sphygmograph. The screw, C, clamps the two component parts in any desired position. A second reserve knife-edge, D, can also be turned up to replace the ordinary one, A, when the cardiac action is extraordinarily forcible. By the screw, K, the compress-spring is fixed. L is the secondary spring, which prevents the recording lever from quitting the knife-edge; it can be thrown out of gear when not required.

The supporting bars are seen at H H; they replacing the side-lappets of the original instrument. On them are fixed uprights, G G G, on which again are attached by screw-clamps two transverse bars for the suspension of the sphygmograph. That to which the clock-work end is joined can only be moved upon the uprights with which it is connected. The other has an additional sliding-piece, I, that allows of the screw-pad portion being independently raised or lowered in a hinged manner.

That this suspending stage will prove of great service in the study of the heart's action there can be no doubt. The presence of the large number of movable centres must, however, render its adjustment somewhat difficult. It will be seen in the figure that the recording plate above the watch-work is of considerable depth. We have found, practically, that it is *never* advantageous to allow the oscillations of the lever to reach nearly so great an amplitude as this will permit; and it is known by all that it is very important that the average level of the lever's tracing should never be far above that line which is perpendicular to the tangent of the circle formed by the lever in its movements, at the point where the two cut one another.

Whilst on the subject of Dr. Galabin's cardiograph and sphygmograph work, we may incidentally draw attention to a point in a paper by him in the January number of the *Journal of Anatomy and Physiology*. Dr. Galabin there comments on Mr. Garrod's law respecting the length of the cardiac systole as it appears in the arterial system—that it is constant for any given pulse-rate, and varies as the cube root of the rate. He remarks, "I have found the length of the systolic portion of the pulse-curve to deviate somewhat considerably from that deduced from the equation. . . . It appears to be approximately true in normal pulses." Would it not have been better if Dr. Galabin had given a larger number of examples—he having confined himself to two, of which one is pathological? In the paper in which the law was announced, the agreement of the measurements with the requirements was very close, and others have been published since, even more satisfactory; it has also been indicated by its author that a pathological condition, like anæmia (the instance taken), is just such an one as that in which a deviation might be expected. Mr. Edgar Thurston, of King's College, has recently read a paper before the Medical Society of that School, which is quite in confirmation of the law as originally stated, from a considerable number of observations on *healthy* subjects.

PHYSICAL SCIENCE IN SCHOOLS

DR. WATTS quite puzzles me. I can see no contradiction between the passages from my essay of 1867 and my letter of 1876, which he silently places in juxtaposition. What I said in 1867 was (p. 261) that "science should be introduced into a school, beginning at the top and going downwards gradually to a point which will be indicated by experience." What I say in 1876 is that experience shows, as far as I can judge, that it is not generally wise to go down very far; that one soon comes to a point at which the loss in teaching science counterbalances the gain. I am quite as sure as ever I was of the value of science in schools, in its right place.

I think that those who advocate the teaching of science to young boys scarcely realise the difficulty of establishing their ground. Some, like Prof. Roscoe (p. 387), admit, when pressed, that it is a question which experience alone can decide, and that they have not had that experience. Liebig, to whom Mr. Gerstl refers (p. 431), was speaking of a different class of schools, in which boys must pick up some useful scientific facts early or not at all. Prof. Henslow's experience is of the same kind. Other philosophers, charmed with the bright intelligence of children when talked to by a Faraday or a Frankland, straightway pronounce an opinion on the relative value of science and classics and mathematics in the early part of a liberal education,—on somewhat insufficient grounds.

The question that this discussion began with was the merits or demerits of the Certificate Examination, in so far as it affected science in schools. That seems to be settled. We have drifted now into a different and most useful discussion on the results of experience in the early teaching of science. The question is this. Given that boys are going to remain under a system of liberal education till eighteen or nineteen, at what stages is it shown by experience that it is wise to introduce the different sciences? It is a question of the *comparative* value of different studies at different ages, not only of what may best be learnt, but of what may least injuriously remain unlearnt, at different ages; and those teachers speak with real weight who can institute such a comparison; men who have watched the processes by which young boys learn different subjects. A man who teaches science only cannot institute such a comparison. He can only say, "I *do* teach young boys something of chemistry and botany, and they *do* gain something." One who teaches mathematics also is so far better off that he can say, "Young boys are more (or less) attentive, active-minded, diligent, when they are doing arithmetic, than when they are at a lesson on physical geography; and they are more (or less) incapable in later years of recovering from the ill effects of neglected arithmetic than of neglected physical geography." One who teaches classics also (as I do for more hours a week than I teach physical science) has wider grounds still for forming a comparison.

Nothing that I see young boys do is as efficient as Latin in completely occupying their minds with perpetually recurring problems which tax attention, memory, judgment, taste. It is quite interesting enough not to be too tiresome. The problems are easy and varied, and the solutions certain and satisfactory. The same sort of young boys who will work hard and cheerfully over a bit of Cæsar or a Latin exercise seem to be a good deal bored by a lesson on physical geography, think botany rather nonsense, and submit silently to the hopeless unintelligibility of "matter and motion." The very same boys will as a rule enjoy an arithmetic lesson and work happily at their practical geometry, or, when well handled, their Euclid. Hence, if I wanted to train up a boy for a scientific career, I would not begin very early with science, but wait till he was thirteen or fourteen.

I admit that the experience of some others is against me.

Mr. Tuckwell (p. 412) speaks warmly, and pronounces my opinion to mean nothing more than that I myself have failed to teach science to young boys. This is a mistake. It means that I have seen the work of others, here and elsewhere. It means not an absolute failure, but a comparative failure, as explained above. It means a summary of the opinions of a considerable number of other men. Mr. Wyles (p. 455) is against me, although he has "never been satisfied with his science teaching." Mr. West (vol. xiii. p. 48) is against me, and his opinion

is a valuable one. But it must be remembered that it is not a personal question, which admits of the simple solution that Mr. Tuckwell can teach science and that Mr. Wilson cannot, but a general one: can science be taught to young boys by the rank and file of science teachers, who are, or will be when they are numerous, neither more nor less able and enthusiastic than the rank and file of classical teachers, very average sort of people? I do not doubt for a moment that my old pupil West can teach little boys science with great advantage, but I doubt very much whether there exist fifty Wests as schoolmasters at any one time in England; and to justify making his practice universal we want to be certain of finding five thousand or fifty thousand such men as teachers. Let it be remembered that very dry and dull men teach classics, and not very badly, while the same men would teach a science class nothing, or worse than nothing.

I wish Dr. Farrar, of Marlborough, would give us his opinion on this whole question. He has had unusual opportunities for forming an opinion and has, no doubt, used them; and I do not know to what conclusions he has arrived.

Mr. Gerstl's proposal to teach facts only—*facts* in italics—is truly fearful to me. I fancy an honest stupid man, like some I know, teaching conscientiously what he considers the *facts* of chemistry or botany, or mechanics; and selecting a book the counterpart of Page's "Advanced Text-book of Geology," or Nicolay's "Physical Geography," bristling with *facts*. The facts of botany, in the hands of most teachers, would be a dreary list I suspect. Mr. Gerstl may teach facts alone successfully, but could the rank and file of our profession do the same?

I will most willingly admit, on the contrary, and maintain, that there exists an early science teaching that is at once useful and well-timed: the excitement and gratification of disinterested curiosity about nature; it is to do for a class, if possible, what an intelligent and encyclopædic father would do for an intelligent child. But how difficult this is for bored and weary schoolmasters! It is so much easier to tell them to get up up pp. x to y in Oliver or Ansted.

One and only one English book do I know that might almost make a stupid man teach one science well; and that is Mrs. Kitchener's "A Year's Botany" (Rivington's). That happily does not teach facts only; but is the expression of the method of a first-rate teacher in such a form as to enable any one to follow it. And yet I tremble as I mention it, for fear some class of tinies shall be ordered to get it and learn the first six pages for their first lesson in botany.

To conclude, therefore, for I will write no more on this matter, what I advise is to interest young boys in science by conversation, by informal teaching, by Natural History Societies, by encouraging collections, aquariums, &c., but not, except in the case of having that rare thing, a genius for the science master (by which I mean a genius for being a master, not a genius for science), to make science a regular subject of class teaching in the lower forms; but to teach the other subjects *well*. Then to bring in science as compulsory on all, first as Physical Geography and Astronomy or Botany, then as Chemistry with laboratory work, and Physics; and after two or three years to let boys choose their own lines. Some will drop it, others will pursue it further. This is one opinion, in brief, on the right place of science in liberal education. Now let us hear what others have to say.

Rugby, April 8 JAMES M. WILSON

NOTES

As might have been expected, Lieut. Cameron met with an enthusiastic reception from a large and distinguished audience at the meeting of the Royal Geographical Society in St. James's Hall on Tuesday night. The hall was crowded, and the Duke of Edinburgh occupied the chair, surrounded by many eminent geographers. His Royal Highness introduced Lieut. Cameron in a few appropriate and appreciative words. The distinguished explorer gave a narrative of his journey from Zanzibar to the West Coast of Africa, going over ground which is no doubt already pretty familiar to our readers. Sir Henry Rawlinson gave a very clear summary of the work which Lieut. Cameron has accomplished. "He has not been a mere explorer," Sir Henry said, "one of those travellers who carry their eyes in their pockets. He always kept his eyes well about him, and the observations which he made, both of an astronomical and of a physical character, are of extraordinary value. The register of observations which he has brought home, and which are now being computed at the Observatory at Greenwich, promise to be of a most important character. They are astonishingly numerous, elaborate, and accurate, and I have great expectation that one consequence of computing those observations will be that we shall have a definite line laid down from one sea to the other across 20 degrees of longitude, which will serve as a fixed mathematical basis of all future geographical explorations of Equatorial Africa. Among the minor objects achieved by Lieutenant Cameron must be noticed his circumnavigation of the great lake Tanganyika and his discovery of the outlet whereby that lake discharges its waters into the great river Lualaba. Another very important matter is the identification as nearly as possible, not absolutely proved by mathematical demonstration, that the Lualaba is the Congo. One of the main objects of the expedition was to follow down the course of that river so as to prove or disprove the identity of the Lualaba and the Congo. Lieut. Cameron was not able, as he explained to you, to carry out that scheme in its entirety, but he collected sufficient information on the spot to render it a matter, not of positive certainty, but in the highest degree of probability, that the two rivers are one and the same. Another great discovery of his is the determination of a new river system between the valley which he followed of the Lolame, and the scene of Dr. Livingstone's discoveries. This valley, which consists of a large river running through a series of lakes, forms, as he fully believes, and as I also believe, the course of the true Lualaba. The observations which he has furnished respecting latitude, longitude, and elevation, amount to the extraordinary number of nearly 5,000; and he took as many as 130 or 140 lunar observations on one single spot." The Geographical Society has only done its duty in awarding to Lieut. Cameron "the blue riband of scientific geography," its principal gold medal of the year.

THE rules of the French Geographical Society strictly forbid the presentation of a prize to any explorer who has not published the narrative of his discoveries. For this reason the motion for granting a medal to Lieut. Cameron at the anniversary meeting this year, was lost. But in the report and the addresses delivered on that occasion, the admiration of the Society was emphatically expressed. The great medal for 1877 will be granted to Lieut. Cameron, we believe, if the necessary condition of publication shall have been complied with.

THERE was a large gathering last Wednesday evening at the Royal Society Conversazione, which passed off very successfully. One of the most attractive features of these meetings is the instruments and apparatus exhibited; in this respect last Wednesday's meeting was quite equal to any former one. A large proportion of the objects exhibited were connected with Mr. Crookes's recent experiments on light. Among these were the following:—(1) The Torsion Balance. (2) The Turbine Radiometer: (3) Radiometer with the vanes blacked on both sides, showing rotation in either direction according to the way the light falls on them. (4) Radiometer showing the very small amount of residual air which is present. (5) Radiometer show-