piece of a flageolet or of a small "whistle"; and the blowing across the end of a tube or a hole in the side of a tube, to cause a key or a flute to sound.

§ 4. Defalcation (III.) is largely operative, and (II.) but little, in many practical cases of most common occurrence in the flow of water. It is probable that much of the foam seen near the sides and in the wake of a screw steamer going at a high speed through glassy-calm water, is due to "vacuum" behind edges and roughnesses causing dissolved air to be extracted from the water. A stiff circular disc of 10-inch diameter, and $1/10$ of an inch thick in its middle, shaped truly to the figure of an oblate ellipsoid of revolution would cause a vacuum¹ to be formed all round its edge, if moved at even so small a velocity as 1 foot per second under water of any depth less than 63 feet; if water were inviscid: and at greater depths the motion would, on the same supposition, be wholly continuous, with no vacuum, and would be exactly in accordance with the unique minimum energy solution.²

While the velocity of the fluid across the equator is 63.7 feet per second, the velocity across each of the two parallel circles whose radii are 4.218 inches (the radius of the equator being 5 inches) is only 1 foot per second.

§ 5. The exceedingly rapid change of shape of the fluid flowing across the equatorial zone between these circles, with velocity at the surface augmenting from 1 foot per second to 63 feet per second in advancing over a distance of less than .85 of an inch of the surface from one of the small circles to the equator, and diminishing again from 63 to 1 from the equator to the other parallel, in a small fraction of a second of time would, if the fluid is water or any other real liquid, give rise, through viscosity, to forces greatly diminishing the maximum velocity, and causing, through fluid pressure, the motion of the water to differ greatly from that of the minimum-energy solution, not only near the equator, or in its wake, or over the rear side of the disk; but over all the front side also, though no doubt much more on the rear side and in the wake, than on the front side, and in the fluid before it.

The viscosity would also, at less depths than 63 feet, have great effect in keeping down the maximum velocity; and it is possible that even at 10 or 20 feet a greater velocity than 1 foot per second might be required to make vacuum round the equator of our disc of 10 inches diameter and the $\frac{1}{2000}$ of an inch radius of curvature which its elliptic meridional section gives it. But it seems quite certain that there must be much forming of vacuum, and consequent extraction of air and rising of bubbles, to the surface, from the somewhat sharp corners, and roughnesses, of iron, in the hull of an ordinary iron sailing ship or steamer, going through the water at twelve knots (that is, 20 ft. per second).

KELVIN.

(To be continued.)

[Correction on previous short article, "Towards the Efficiency of Sails, &c." In last line but two, for 2π substitute $\frac{1}{2}\pi$. In last line but one, delete 4, and for 8 substitute 32.]

¹ Single word to denote space vacated by water.

² From the elementary hydrokinetics of the motion of an ellipsoid through an inviscid incompressible fluid, originated by Green, who first gave the solution for the case of translational motion of the ellipsoid, we know that, if θ denoting the angle between the axis of an oblate ellipsoid of revolution, of which the equatorial and polar areas are a , b , the velocity of the fluid flowing over this point of the surface is

$$\frac{(a^2 - b^2)V \sin \theta}{b \left\{ b + \frac{a^2}{\sqrt{(a^2 - b^2)}} \sin^{-1} \sqrt{\frac{(a^2 - b^2)}{a}} \right\}},$$

if the velocity of the fluid at great distances from the solid is V , and in parallel lines, and the solid is held fixed in the fluid, with its axis parallel to these lines. Taking $a = 100b$ in this formula, we reduce it to $\frac{200}{\pi} V \sin \theta$ approximately within 1 per cent.; and taking $\sin \theta = 1$, and $V = 1$ foot per second, we find 63.7 feet per second for the velocity across the equator. Hence the gravitational head corresponding to the "negative-pressure" is $(63.7^2 - 1^2)/64.4$, or very approximately 63 feet, which proves the statement in the text.

SCIENCE, IN SCHOOL AND AFTER SCHOOL.

IT is an unfortunate accident of the conditions under which instruction in science has grown up, that in speaking of science teaching two essentially dissimilar things should be confused. This confusion has very seriously affected—and still affects—the development of method in this country. It arises from the fact that, twenty or thirty years ago at least, the ordinary schoolmaster was quite without the knowledge necessary to teach science, and that even when his scientific knowledge was a measurable quantity, that ignorance of psychology which was and which remains one of his most constant characteristics, rendered him incapable of innovations upon the tradition of mental training he cherished. Consequently what knowledge people obtained of the growing body of science came after the elementary stage of education was over, when their minds and senses had already received a considerable amount of cultivation and were, for good or evil, definitely developed in a prescribed way. The teaching given, therefore, did not aspire to be so much educational as *instructive*; it made the best of a bad job, and without any belated attempts to alter the fundamental intellectual mechanism, placed therein so much of the new facts and views as the circumstances permitted. It was addressed primarily to adolescence and to the adult, its methods were by lecture, diagram and text-book, and the written examination or a practical examination, turning chiefly on the identification of specimens or the interpretation of diagrams, was the adequate measure of its value. Such teaching can affect the taught only through their opinions and knowledge; it can discover scientific capacity, but it can neither develop nor very largely increase it, because it comes too late in the mental life. It is typically represented by the innumerable classes over which the Science and Art Department presides.

On the other hand, we have the science teaching that is *educational*, that takes the pupil still undeveloped and trains hand, eye, and mind together, enlarges the scope of the observation, and stimulates the development of the reasoning power. Such science teaching occurs at present most abundantly in theoretical pedagogics. It is, however, undoubtedly the proper science teaching for the school, if science is to have a place in the school. For it is universally conceded nowadays that the school is a training place, that there the vessel is moulded rather than filled, and that the only justification for the introduction of science is its educational value. Equally indubitable is it that it should be confined to school limits. An attempt to make the adult science teaching educational in the same sense, would be—to complete the image—extremely like putting a well-baked—if imperfect—vessel back upon the potter's wheel.

Now, hitherto the chief influence of this confusion has been to hamper truly educational science teaching in schools. Those who had as adults studied science under the Science and Art Department, or in University lecture theatres, took their text-books and the methods under which they had acquired their knowledge into the school, where the conditions were altogether different. The course of science lessons began as a lecture in which the class listened to colourable imitations at second or third hand of this or that eminent exponent of scientific theory. The more discerning teachers after a time realised the futility of requiring genuine lecture notes from such immature minds, and supplied the deficiency by dictating a colourable imitation. They also provided copies on the blackboard for such original sketches as were required, and indeed went to very considerable pains to keep the outward appearance of the lecture system intact. Examiners of schools—being selected without the slightest reference to their capacity to examine—fell very readily into this view, that school science-teaching was adult

science-teaching in miniature; as some parents hold that infant costume should be a simple and economical adaptation of the parental garments. And so an elaborate system of lecturing, note dictating, "model answer" grinding, has been evolved, which is not only not educational and a grievous waste of the pupils' energies, but which seriously discredits the claims of science upon the school time, in the eyes of ordinary educated people.

This has been particularly the case in many middle class schools, though the recent abolition of the second class pass in the May examination has done much, as the Forty-first Report of the Department shows, towards mending the mischief. In connection with countless higher grade and small grammar schools, classes, containing as a rule only elementary pupils, and aiming really only at second class passes, have been organised from year to year. Not only was the science-teaching given in the evening classes, but a considerable portion of the daytime was devoted to model answer drill and to mechanical copying out from the text-book. The minimum of apparatus required by the Department formed a picturesque addition to the schoolroom. This discipline resulted in remunerative grants for second class passes, but it resulted in very little else, except perhaps a certain relaxation of the pupil's handwriting and a certain facility in the misuse of scientific phrases. The certificates were framed and glazed, the teacher added a few modest comforts to his home, and there the matter ended.

The examinations of the Science and Art Department were scarcely to blame in this matter, although the blame has been generously awarded them. The Science and Art Department is a large and convenient mark, it is perfectly safe to throw at, and to attack it has something of the romantic effect of David against Goliath. But we must remember that its classes were primarily, as they are still in intention, continuation and adult classes, an outcome of the Mechanics' Institute movement, and it was an unforeseen accident, and one the full bearing of which only became apparent in the course of years, that they should so seriously affect the teaching of middle-class, and even of the higher standards of elementary, schools. For their proper purpose as a test of lecture teaching, the departmental examinations are generally efficient. Far more blameworthy are examining bodies whose work is specially directed to school needs. The College of Preceptors, for instance, while subsidising lecturers upon Educational Theory, has done nothing to promote practical work in schools, and many of its examinations set a premium upon that vicious lecture and text-book cramming which educational theory condemns. And in public schools over which the Department has no influence, young gentlemen from the older universities, beginning educators without of course the faintest knowledge of educational technique, set up precisely the same imitation of the professorial course. We have in consequence such a standing argument against science teaching as that naïve testimony of a prominent headmaster, that he found boys who had followed the classical course for some years, and who then took up "science as beginners," speedily outstripped those who, to the exclusion of literary work, had been engaged during the same time in what he regarded as scientific studies.

So far the confusion between the two forms of elementary instruction has hampered science-teaching. But there can be no doubt that the educational reformer is abroad. A large, if somewhat inchoate, body of criticism has grown up, and good resolutions in the matter are epidemic. A really educational scheme of instruction in physics and chemistry now exists, having its base upon the Kindergarten, and developing side by side with elementary work in mathematics. Mr. Earl's recently published book upon Physical Measurements is an admirable exposition of what is here intended by educa-

tional science-teaching. In this, information is entirely subordinated to mental development. His course is devoted to the measurement of space, mass and time, and to the observation and methods of recording various changes involving precise determinations. The first exercise requires the pupil to "measure the size or dimensions in inches of the paper on which you are writing, using for your standard a strip of paper one inch in length, and which you have divided into halves, quarters, and eighths"; and the book concludes with experiments upon torsion and the rotation of suspended bodies. The course must inevitably constitute a firm foundation of definite concepts, and develop a clear and interrogative habit of mind. It marks the line along which school science teaching must move in the future, if it is to attain that predominance which its advocates claim for it. Yet at the same time it may not be premature to notice that the new movement has its dangers.

These dangers arise from the confusion between the two distinct forms of science-teaching whose existence is necessitated by the present condition of things. In the past the error has been to treat children like adults; in the future it may be that adults will be treated like children. Such exercises as the one we have noticed, are excellent in developing concepts, but scarcely anything could be devised more irksome and exasperating to a mind already provided with a basis of definite ideas. Nothing, for instance, could be better calculated to discourage an intelligent student of eighteen or nineteen, curious about physics, than a day or so spent in manufacturing an unreliable millimetre scale. The problems of the science are already more or less vaguely in his mind, and there is every reason why these should be made the starting-point. To produce an intellectual parallel to the spiritual re-birth, is as impossible as it would be to refer an unsatisfactory chicken back to the egg to reconsider its ontogeny. We have now, and shall have for an indefinite number of years, to provide for the needs of a great number of people whose intellectual development is nearly or quite at an end, whose curiosity about nature is already aroused, and whose practical needs are also pressing for scientific information, and yet who are ignorant of any but the veriest commonplaces of science. For them the Science and Art Department classes were designed and are well adapted. It will be an unfortunate thing if the criticisms of the educational reformer should so far overshoot the mark as to affect their instruction. Yet one might suggest that a downward age limit, similar to that of the London University Matriculation, might save many a schoolmaster from the temptations of the possibility of grant-earning—a temptation, however, from which the abolition of the second class in the elementary stage has already to some extent relieved him.

H. G. WELLS.

WITH PROF. HEIM IN THE EASTERN ALPS.

THE excursion with Prof. A. Heim, of Zürich, which came to a happy end on September 15 at Lugano, was one full of interest to students of tectonic geology. It afforded those who were fortunate enough to take part a rare opportunity of seeing in the field some of the classic sections with which the name of Heim has been for many years associated, and, better still, of seeing the genial author of the "*Mechanismus der Gebirgsbildung*" himself climbing his native Alps as nimbly as a chamois, and expounding his own work face to face with the hard facts on which his conclusions have been based. The party, numbering at the outset twenty-three, left Zürich on the 3rd, after the close of the Geological Congress, and took train to Appenzel, spending the first night at Weissbad, a village nestling peacefully beneath the rugged peaks of the Säntis Range. This magnificent buttress of the