

will come the time of fullness of the development of applied science.

Mathematics has been a well-nigh indispensable tool in the development of the natural sciences and their applications. On the other hand the natural sciences and particular problems set by science have challenged the ability of mathematicians and spurred them on to the achievement of larger results in pure mathematics. Whoever can strike this flint of mathematics upon the steel of natural science and produce fire is doing the world service. The oftener fire is produced the greater will be the development of both mathematics and natural science.

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EDUCATION AFTER THE WAR

THE sharp debate on the place of science in education which took place recently in the House of Lords between Lord Haldane on the one side and Lord Cromer and Viscount Bryce on the other side is an example of the kind of misunderstanding which it is necessary to eliminate if we here in the United States and you in England are to act wisely in the matter of education after the war.

In his sesquicentennial address at Princeton University nineteen years ago Woodrow Wilson said that if he was not mistaken the "scientific spirit" of the age is doing us a great disservice, working in us a certain great degeneracy; and yet he said that he had no indictment against science itself, but only a warning to utter against the atmosphere which has stolen from our laboratories and lecture rooms and into the general air of the world at large. It is a noxious intoxicating gas which has somehow got into the lungs of the rest of us, a gas which it would seem forms only in the outer air.

Now it is not easy even for one of Dr. Wilson's training to express himself with perfect clearness in a matter of this kind; and although we are in full sympathy with what we understand Dr. Wilson's point of view to be,

we do not like his use of the term "scientific spirit." The true scientific spirit, the spirit of such men as Kelvin and Helmholtz, is beyond criticism; but the great things such men have done have brought upon us the most distressing and stupid form of idolatry the world has ever seen, and the men who have the true scientific spirit are the only men, as a rule, who are free from it.

Science is *finding out* and *learning how*, whereas most people think of science only in terms of its material results. These results have indeed fascinated the crowd, and the great majority of men have adopted a scale of physical values for everything in life "with a consequent neglect of quality and a denial of human value in everything. We have a philosophy of rectangular beatitudes and spherical benevolences, a theology of universal indulgence, a jurisprudence which will hang no rogues; all of which means, in the root, incapacity of discerning worth and unworth in anything and least of all in man. Whereas, nature and heaven command us, at our peril, to discern worth from unworth in everything and most of all in man."

"Our real problem now, as always, is 'Who is best man?' and the fates forgive much—forgive the wildest, fiercest and crudest experiments—if fairly made in the settling of that question. Theft and blood-guiltiness are not pleasing in their sight, and yet the favoring powers of the spiritual and material worlds will confirm to you your stolen goods, and their noblest voices applaud the lifting of your spear and rehearse the sculpture of your shield, if only your robbing and slaying have been done in fair arbitrament of that question 'Who is best man?' But if you refuse such inquiry you will come at last to face the same question wrong side upwards, and your robbing and slaying must then be done to find out 'Who is *worst* man?' which in so wide an order of inverted merit is indeed not easy."

This impassioned statement of a great English writer and moralist seems to us to touch the essence of all unfriendliness towards the sciences among seriously thoughtful men, and although this unfriendliness is largely mis-

directed it must be admitted that "side by side with great advances in material prosperity due largely to the applications of science there has been a vast deterioration of character," as Lord Cromer expressed it.

Indeed Lord Cromer applied his statement particularly to the Germans, but the deterioration of character, which has shown itself chiefly in the misuse of wealth and opportunity, is by no means confined to the Germans. In some respects, indeed, it would seem that the English and our own Americans have sinned more than the Germans.

Lord Haldane and all champions of science teaching should understand that most of the unfriendliness towards science is a hatred of material worship; and Lord Cromer and Viscount Bryce should understand that in their opposition to the extension of science teaching they are misdirecting their hatred of idolatry, and placing themselves in exactly the position of the hand spinners when they opposed the introduction of improved machinery years ago. It is now as much of a mistake to oppose the fullest and widest possible development of finding out and learning how as it was years ago to oppose labor-saving machinery; only it is quite necessary to make readjustments for the conservation of character and morals. Indeed this necessity has shown itself most distinctly in our reluctance to make just such readjustments among those whose labor has been so wonderfully "saved" by machinery!

In the early days at the University of Kansas (where one of us graduated thirty years ago) when the crudities of pioneer living were still very much in evidence the question was frequently raised among the young men of the faculty who had come from older communities in the east "Can the finer aspects of civilization, literature and the fine arts, ever flourish in this prairie country?" And a smaller faculty group, sensitized by the raw conditions, were very much alive to the question which has been fought over in every college "This new thing, science, what menace does it hold for literature and the fine arts?" Let one consider what must have been the state

of mind of an immigrant group of intellectuals in grasshopper times in Kansas!

Nothing, perhaps, is farther from the ideals and methods of the mathematical sciences than literature and music and painting and sculpture, and yet many of our greatest scientists and engineers have held the artistic temperament to be the most important qualification for the investigator or builder. It certainly is not foolish, at any rate, to consider seriously the unfriendliness towards science teaching among those whose work is more closely connected with human things. Lord Cromer and Viscount Bryce no doubt agree with Woodrow Wilson in having no indictment against science itself, but they seem somehow to be unfriendly towards science teaching.

Da wird der Geist Euch wohl dressirt
In spanische Stiefeln eingescuert.

Indeed there is a phase of science teaching for which there is an unfriendly feeling among those whose work is closely connected with experimental science and engineering, namely, formal mathematics teaching, and nothing has ever been said which can be more justly applied in criticism of our conventional courses in mathematics than the following criticism of conventionalized art. The criticism is expressed in terms of the contrast between the two paths of art and it is illustrated by examples chosen from early barbarisms.

The substitution of conventionalism for sympathy with observed life is the first characteristic of the hopeless work of all ages, and it is emi-



FIG. 1. An angel of the eighth century. The beginnings of art in England.

nently manifested in the accompanying picture of an angel from a psalter of the eighth century which is to be found in the library of St. John's College, Cambridge. This angel is a barbarism

from which nothing could emerge, for which no future was possible but extinction. It represents an utterly dead school of art which closed its eyes to natural facts (for however ignorant a person may be he need only look at a human being to see that it has a mouth as well as eyes) and made the attempt to adorn or idealize natural facts according to its own notions (for it put red spots in the middle of the hands and sharpened the thumbs, thinking to improve them). Here you have an example of the worst that is possible in idealism. Whenever people don't look at nature they always think they can improve her.

From this dead barbarism let us turn to a living barbarism, to work done by hands as rude and by minds as uninformed, let us turn to a picture of the Serpent Beguiling Eve, from the Church of St. Ambrogio of Milan. Its date is not known, but it is barbarous enough for any date: but rude and ludicrous as the sketch is, it does certainly have the elements of life in it. The workman's whole aim was straight at the facts, and not merely at the facts but at the very heart of the facts, for he did indeed show Eve's state of mind, that she is pleased at being flattered and yet in an uncomfortable mood of hesitation; some look of listening, of complacency and embarrassment he did verily get into the picture; note the eyes slightly



FIG. 2. The Serpent Beguiling Eve. The beginnings of art in Italy.

askance, the lips compressed and the right hand nervously grasping the left arm. Nothing was impossible to the people who began their art thus. The world was open to them and all that is in it; whereas nothing was possible to the man who did the symmetrical angel, the world was keyless to him. He built a cell for himself in which he was barred up forever.

Our conventionalized courses in mathematics do not, however, take strong enough hold on young men to shut them up, as in a cell, forever! No, they certainly do not! But

these courses do tend to separate ordinary mathematical ideas from sense material: whereas the very essence of physics and chemistry is to develop mathematical ideas in connection with sense material.

Let no one imagine that we, in our unfriendliness towards conventional mathematics teaching fail to appreciate the necessity of the kind of precise thinking which is peculiar to the mathematical sciences, although much that has been said on this subject by mathematicians seems to us to be only a near-vision of that abstract heaven which, according to William James, is the one refuge of tender-minded philosophers, but which to the tough-minded is merely an empty dream.

Nothing in this world is necessary which can be avoided, and it is much better to attempt to show that we can not get along without precise thinking than it is to pronounce eulogy thereon; and if one speaks of the necessity of precise ideas as a distressing thing, which it certainly is to many young men who aspire to be engineers and scientists, one may as it were by stealth gain entrance to their primitive minds and convince them that men do not now live by hunting and fishing. This is what we have tried to do in our "Introduction to Mechanics."¹

Imagine a never-to-be-escaped human need of a twenty-foot arm. What age-long development, and what unthinkable pains! It is easier to build a steam shovel! All of which means that *homo sapiens* is now bent towards social inheritance; but social inheritance has its own pains, as many know who burn the midnight oil.

Weh dem die Enkeln sind.²

How shocking to reduce the tender-minded philosopher's love for perfect precision to a materialistic preference for steam shovels as

¹ See our "Mechanics and Heat," The Macmillan Co., 1910. This essay is reprinted under the title The Study of Science in "Bill's School and Mine," published by Franklin, MacNutt and Charles, South Bethlehem, Pennsylvania, 1913.

² This was addressed by Goethe directly to a young student "Weh dir das du ein Enkel bist."

opposed to immeasurable pains of birth! And to make mathematical philosophy appear as a dire necessity rather than a thing to be chosen for its own sake.³ And then to urge⁴ with that lover of paradox, Gilbert Chesterton, that the serious spiritual and philosophic objection to steam shovels is not that men work at them and pay for them and make them very ugly, nor even that men are killed by them, but merely that men do not play at them! Imagine a group of sportsmen cavorting over a ten-thousand acre field tossing and catching a Brobdingnagian ball in steam shovels! Is it conceivable that the one objection to the steam shovel might have been eventually overcome if the Great War had not come upon us?

The greatest danger of our time is the confusion of boundaries between thing-philosophy and human-philosophy, between the philosophy of material conquest and power and that intimate philosophy of comfort which makes life not easy but worth while. When these boundaries are rectified there will be a philosophy of steam shovels recognized and used as such, and another philosophy of living; and the most laughable spectacle in the world will have passed by forever, namely, the Bergson type of philosopher with his following flock of men and women captivated by humbug in the name of an easy, capital-letter science raised heaven-high above all dirt and slime!

W. S. FRANKLIN,
BARRY MACNUTT

THE VALUE OF THE SANITARY SURVEY

It would seem unnecessary to again dwell upon the old topic that analytical examinations, whether chemical or bacteriological or both, utterly fail in a large number of cases to supply sufficient data whereon to build an opinion as to the sanitary value of a water; but the old belief is deep-seated and dies hard.

³ This we have tried to do in our "Introduction to Mechanics."

⁴ See preface to Franklin and MacNutt's "Elements of Electricity and Magnetism," The Macmillan Co., 1908.

From time to time therefore it appears necessary to call attention to the fact that, however valuable the information gained in the laboratory may be, a thorough personal knowledge of the conditions surrounding the source whence the water comes and the method used for taking the sample entirely outweigh the analytical data.

Take an instance: Mr. N. S. Hill had reported to him the presence of *B. Coli* in water from flowing artesian wells, over which wells he had jurisdiction; and he was naturally not a little pained and mystified because of the character of such report, the accuracy of which was beyond dispute. The water rose under pressure sufficient to carry it fifteen or twenty feet above the ground surface and it thence fell in open streams into the funnel-shaped ends of vertical pipes connected directly with the supply main. Deep waters may contain bacteria, especially chromogenic varieties, and even pathogenic forms may occur therein because of unsuspected channel ways in the rock; but under the conditions obtaining in this instance the adverse report of the examiner was unlooked for and Mr. Hill's surprise was fully warranted.

Upon carefully conducted inspection it was observed that at certain times of the day the rims of the above-mentioned funnel-shaped pipe terminals were lined with sparrows that roosted, as often as not, with heads pointed outward.

Another case of pollution due to birds had a more serious ending. The contractor was confident of the purity of the water he had engaged to supply and rested his case upon the report of a bacteriologist selected by both parties. The report was adverse to the fitness of the water and caused financial failure of the contractor. When it was too late to rectify the error it was discovered that the small basin which caught the water as delivered from the ground had served as a roosting place for birds and from that basin, rather than from the falling stream, the sample had been taken.

During a legal inquiry concerning what could or could not be done by the addition of alum to a city water-supply, much discussion