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THE SCIENCE *vs.* THE ART OF CHEMISTRY.

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THE attitude of the world in general toward chemistry is peculiar, and, as this paper is intended to show, it is not what it ought to be. This is due in turn to a peculiarity of the science itself, which distinguishes it from most other sciences. We refer to its close connection with matters of every-day experience, and of practical importance. It is unnecessary to dilate here upon this close connection. Every one who has any conception whatever of chemistry recognizes it to a greater or less extent. But, owing to this close connection, the unscientific world has grown into the habit of considering the practical problems as the problems *par excellence* of chemistry, and, having once recognized *some* object of the science, they inquire no further, and hence they fail to recognize its most important and only legitimate object.

In this respect chemistry as well as physics is unfortunate; though at the present day physics has an advantage over chemistry. Time was when the world looked upon physics also as mainly a practical science; but, of late, by the efforts of gentlemen of high standing, the attention of the people has been drawn to some of the higher problems of the science, and these have been rendered intensely interesting to every thinking being. Some of the grander results of physical investigation have also become familiar to the world, and have served to increase the respect for the science. The great truths of the conservation of energy and the transformations of energy; the application of the spectroscope to the investigation of heavenly as well as earthly bodies; the undulatory theory of heat; the nature of sound, and the beautiful relations of sounds to each other—these are all matters with which the world is fast growing familiar; and the popular discussion of these subjects is doing something, perhaps a great deal, to elevate mankind above that condition of superstition and darkness which still is the portion of most of the world. The great generalizations of science are ennobling, and, in the exercise which they afford the intellect, are productive of happiness of a very high order. Whatever good we may recognize, as having been effected by the practical application of electricity, heat, and other natural agents, to the satisfaction of the wants of man—and the good is undoubtedly great—an infinitely greater good springs from the dissemination of the immortal truths of physics. But the latter good is quietly effected; it consists in a growth of the ideas of the world, and thus contributes to the growth of manhood. We do not always recognize it, but it is ever present. With the growth of ideas concerning the physical universe, the ideas concerning the Creator of the universe must grow larger, broader, grander, and we must worship with a truer adoration, and a feeling of more perfect reverence.

If we turn again to chemistry, we shall see that while its importance is almost universally recognized; while the number of those who devote themselves to its study is increasing every year; while immense sums of money are yearly spent for the

building and support of palatial laboratories; while the press, recognizing the popular appreciation of the science, furnishes, in its own peculiar way, brief records of its advance—still we can point to very little connected with chemistry which, for its elevating influence upon mankind, can be compared with the great physical truths above referred to. That which is caught at and served up for the public is taken from the lower portions of the science, while the higher portions pass on, scarcely if ever coming in contact with the populace. The public knows when a new dye is discovered; it knows when the poison has been found in some strange stomach; it knows when a new milk for babes has been concocted; it knows when precious metals have been detected in the depths of the earth; it knows all these things because it is promptly informed in regard to them; and it is right and good that the information should be given, and that these things should be known. It is plain, however, that a thousand dyes might be discovered; that a thousand murderers might be brought to justice through the aid of the chemist; that varieties innumerable of milk for babes might be concocted; or that mines upon mines of gold might be unearthed without the slightest ennobling or elevating influence being exerted upon the mass of mankind. All of these things would be valuable—undoubtedly—but their value would be of a very material kind. It is certain that this material value is that which is most easily recognized, which appeals most directly to the public; and hence plainly, in the public mind, the importance of chemistry is measured by the standards of this value. The reputations of chemists, too, depend upon the greater or less extent to which they devote themselves to practical questions. He who is frequently on the stand to testify in regard to cases of poisoning; he who succeeds in presenting to the world some new compound which can be used practically; he who detects impurities in our food or tells us of poisons where their presence must be of importance to us—this man is, to the public, the *chemist*. Ask ninety-nine men out of a hundred what a chemist is, and they will give a definition of one who practises the art of chemistry, rather than of one who is devoted to the science of chemistry.

This statement is true, whether we speak of the mass of mankind, or of educated and even professional men. The reputation of the science, at the present time, is such that few men conceive of the true science independently of the art of chemistry. This is true, further, not alone in this country, but in Germany, which may rightly be called the seat of chemistry—with this difference, however: In Germany the true scientific spirit is so deeply imbedded in the educated mind, that a subject which has a practical side is apt to be looked upon in a disrespectful manner; and so it happens that those who ought to know better are inclined to speak contemptuously of chemistry, simply because they accept the popular idea of the science as the true one, not stopping to ask whether there is anything higher in the subject than that which the public recognizes. An anecdote which illustrates this matter clearly may not be out of place here. Two students at a German university, one a philologist, the other a chemist, were conversing, on the eve of their examination for the degree of doctor of philosophy. The philologist asked, "What is the subject of your thesis?" The chemist answered: "Piperic acid; I have been working on the subject for a year and a half." When it was further stated, in reply to inquiries, that this acid could not, so far as was known, be used for any practical purpose, the philologist was loud in his expressions of pity for one who could work a year and a half without accomplishing something which would tend directly to improve the material condition of our race. A counter-question in regard to the subject of the thesis of the philologist elicited the answer: "My subject is an exceedingly interesting one; I have already written nearly a hundred pages on it and have not yet finished: it is the *preposition AD in Tacitus*" It is needless to add that he was unable to state to what practical use the preposition *ad* could be put. The condition of mind toward chemistry which this young man thus betrayed is that which we should

most frequently find in educated as well as uneducated men in this and other countries. We would not throw ridicule upon the enthusiasm displayed—we admire it; but we ask to be allowed to have a similar enthusiasm for our prepositions.

We have thus found the chief cause for the idea commonly held in regard to the nature of chemistry to be that peculiarity of chemistry among the sciences which gives it its close connection with practical matters. It has already been remarked that it is right that this portion of chemistry should be recognized and appreciated. This recognition and appreciation should be encouraged, but not to such an extent as to sacrifice any appreciation which it is possible to awaken for the higher portions of the science.

There is another direct cause for the popular conception of chemistry, growing out of the more general and indirect cause already considered. This consists in bad attempts to present the truths of the science to the people. The popular lectures on chemistry which are usually delivered are not scientific lectures; they are frequently utterly lacking in everything that characterizes scientific method; and they leave no further impression on the minds of the hearers than that chemistry is a subject which enables men with the requisite degree of skill to become successful showmen. Though the lecturer is perhaps more respected, still the character of the respect which he has called forth is akin to that called forth by any clever trickster. It is unfortunate that experiments, originally devised for the purpose of teaching facts, should have come to be employed simply for the sake of their æsthetic effects. There can certainly be no harm in making an experiment a thing of beauty, so long as its real object is not by this means interfered with; indeed, this may be advisable, in order more strongly to impress upon the minds of the hearers the facts which are to be taught, but the tendency is very strong toward the condition above described: the science is made to serve the purposes of showmen, and the rabble shout the more, the greater the display. Those who serve up this class of lectures are doing positive harm by belittling the science whose name they profane; and they are also doing negative harm by failing to make use of the opportunities afforded them to draw the minds of men upward to higher conceptions, and thus of elevating mankind. They neither recognize the science nor the art of chemistry, but by their actions teach that it is a pastime of no particular value.

In the foregoing we have drawn a line between the science and the art of chemistry. The character of the art is perfectly plain to every one. He who analyzes substances in order to decide questions solely of practical importance; who examines the properties of substances solely with a view of determining the practical uses to which these substances can be put; whose only problem relates to the applications of the truths of chemistry to the uses of man—*he* practises the art of chemistry.

But it is time to inquire what the science is, and what its relation to the art is. A science is a collection of principles, well established, applying to a certain class of phenomena. The science, of chemistry is that particular science which treats of the action of bodies upon each other, in so far as this action causes a change in the composition of the bodies. All the so-called natural laws which govern this kind of action belong legitimately to the field of chemistry. The science is, strictly speaking, a part of that broader science which treats of the action of matter upon matter, viz., physics; but it is usual to consider the two as separate sciences. Its first object is to determine the laws of combination and decomposition of bodies, and its state of perfection will be reached when so much is known concerning these laws that we shall be able in every case to foretell what changes will ensue when two or more bodies are brought together, or when certain influences are brought to bear upon a body. We are so very far from this perfect state at present that we cannot even say what kind of reasoning processes will be necessary to enable us to draw the proper conclusions from given facts. It appears

probable, however, that chemistry will gradually develop into a true mathematical science, and that, having reached this state, chemists will determine the orbits of atoms, their rates of motion, their perturbations by methods similar to those so long employed in studying the problems of astronomy. Although we are far from the perfect state of the science, still every advance made in it is a step toward the end. From time to time material enough is collected to enable some one to make a comprehensive generalization. These generalizations we admire, but we sometimes forget that they never could have been made had not a myriad of workers from day to day furnished the material; themselves often unconscious of the importance of the real work they were doing, but believing that every fact established, however insignificant in itself, every error of previous observers, however slight, corrected, would at some time serve a purpose in the growth of the science. Dalton's law of multiple proportions; the law of Dulong and Petit connecting the specific heat and the atomic weight of the elements; Avogadro's hypothesis relating to the connection between molecular weights and the volumes of gaseous compounds, would still have been of the future, had it not been for the efforts of a great many scientific workers, contributing their mites day by day.

Though we thus recognize a growth of the science of chemistry, entirely independent of any practical applications of its facts, it is of course true that the latter follow closely in the footsteps of the former. When, then, we rejoice in any useful application, let us remember that it could never have been made had the science itself, as a science, not advanced.

It happens in this country particularly that a man may both practise the art of chemistry and at the same time be a worker in the field of scientific chemistry. This is due to the fact that it is necessary for the men to live, and there are very few positions in the country which enable their incumbents to devote themselves to the pure science of chemistry without obliging them at the same time to look for additional means of support to that furnished by the positions themselves. This additional means of support can usually be found most readily in the practice of the art of chemistry. Too often, time that could and would be devoted to grappling with the problems of the science is given up to the art in order to keep the purse supplied. Every properly-constituted scientific man, however, who is obliged to so apply his powers as to bring himself immediate and material rewards, feels that he is doing something which he would rather not do, and that, by applying himself to his science proper, he could in the end be of much more service to the world. It is apt to be the case, too, that he who begins to slight the science and to favor the art will at last entirely sacrifice the former for the latter, and we see too many teachers of chemistry in this country at the present day who are devoting their time to the art rather than to the science of chemistry; a circumstance which has the most pernicious effect upon the growth of the science among us, for the students who are placed under the influences mentioned are not stimulated, as they should be, to consider the higher questions of the science, but go out into the world only to keep alive the popular and erroneous idea concerning the nature of chemistry.

Finally, if we have correctly represented the attitude of the world toward chemistry, and correctly stated the causes of this attitude, it is plain that the world is not to be blamed, but rather, if fault is to be found, it must be with the chemists themselves. To them we must look for deliverance. They may by united efforts bring about the desired changes. But how?

Two general methods may be indicated. In the first place, the teaching of chemistry must be of a higher order than it is at present. In some of the higher institutions of learning students must be carried through strictly scientific courses; they must be brought face to face with the great questions of the science, and shown how to work at

the solution of existing problems; and they must go forth with high and true conceptions concerning their science, prepared to influence those with whom they come in contact, and to give them, too, correct ideas. A great deal can thus be done in the right direction by a single strong man teaching properly, and the influence is very quickly felt. We need only refer to the influence of Agassiz on the science of zoölogy in this country, to show what results may be reached by a single man who is working in the proper way. A change in the methods of teaching in our higher institutions of learning, then, is the chief thing to which we are to look for an improvement in the popular conception of our science. But there is another means at our command which is very rarely taken advantage of by scientific chemists. This consists in popular presentations of the higher truths of the science, either in the form of lectures or of articles in magazines which are read by the public. A great deal of good can be accomplished in this way, if the work is properly done. There are chapters of great inherent interest treating of matter which belongs in the domain of the science of chemistry, and these are rarely alluded to in popular lectures or articles. If more stress were laid upon such subjects, and less upon the merely practical portions of the science, something would be done in the way of drawing the attention of the public toward the higher questions, and thus that good influence which was above referred to as resulting from popular discussions of the great truths of physics would also be felt, to some extent, in connection with chemistry. Thus, too, there would gradually grow up a respect for the science as well as for the art of chemistry.

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