personal equation from other forms is very considerable. When the Greenwich catalogue for 1890 is published, it will be necessary to find out in some manner the personal error depending on magnitude of the chronographic right ascensions of that catalogue, but these will have in them a personal element depending on the habits of the observers by whom the transits have been registered, and this will be complicated unless it is shown that the various observers have been brought to a more uniform habit than is generally supposed. The comparison of the catalogue for 1890 with the zones of the A. G. C. will at a later time furnish a great amount of interesting information, but which at present needs the careful study of the methods of observation and elements of reduction which have been employed in the zones already observed by eye and ear as well as by chronograph.

The catalogue of Dr. Romberg* is the best standard of comparison for the A. G. C. eye-and-ear zones, as it was observed in the years 1874 to 1880 with a powerful meridian circle whose aperture was large enough to render all the A. G. C. stars distinctly visible, and the standard of reduction is the same as for the A. G. C., viz.: Wagner's right ascensions for 1865 and Nyrén's declinations for the same epoch.

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* I regret to say that this excellent observer has passed away since these words were written.

SOME DANGERS OF THE ABUSE OF CHEMICAL FORMULAS.

WHEN Thomson made his memorable visit to Dalton, in Manchester, nearly one hundred years ago, and was shown the system of symbols by which Dalton hoped to make clear his ideas as to atoms and their combinations, he was enthusiastic as to the future usefulness of such a system. And, although the system was clumsy and inadequate to the task of properly representing the great mass of chemical facts, it contained the valuable idea of graphic representation which was to be ingeniously elaborated and developed by later masters of the science.

It was through Berzelius next that chemical symbols were made simpler and clearer. So manifest was their usefulness that they speedily claimed the additional advantage of almost universal acceptance. Local adoption only, the use by chemists of one nationality or the followers of one master would have proved a most serious bar to the advancement of the science. We can fancy the confusion which would arise from the use of different systems at present, but, happily, such a picture exists in the imagination only. The science has one universal language of symbols which those of every tongue can read and understand. The advantages of such a system need not be dwelt upon. I purpose rather pointing out a few possible dangers and abuses.

The simple application of symbols in the time of Berzelius has become more complicated as the science has developed and the knowledge of both composition and constitution of chemical bodies has increased. Intended at first to represent elements and single compounds, the symbols have been developed into complex formulas, and these have been united into algebraic equations in the effort to make them represent as much as possible of the knowledge so laboriously acquired by multiplied experiments. The system has become in truth the shorthand of chemistry.

While its great usefulness is not to be underestimated, the limitations of the system should be duly recognized. In the first place, it can only partially represent the mathematical relations of the science. Again, there is no mode of indicating in an equation the physical forces which always accompany chemical reactions. These relations are of especial importance and yet there is no adequate mode of expressing them. It is questionable how far such important relations as the electro-chemical and those of chemical affinity itself can be deciphered from those equations. Certain it is that the best constructed equation frequently represents only one of many reactions occurring at the same time and under the same conditions, and there is no way of indicating under what conditions the given equation is true. It often happens, especially in organic chemistry, that an equation upon which much stress is laid is really a secondary and subordinate one, and since this is not indicated by the formula the student may be mislead.

Such questions as whether all of these more or less desirable matters can ever be represented by any system, or whether the present system is not the most perfect which we can hope for, do not come within the scope of the present discussion. It is sufficient to point out that the system is not flawless. We must all acknowledge that it is indispensable to chemists and, being something more than a mere shorthand system, greatly aids him in his work.

For these reasons all young chemists must be properly initiated and inducted into the mysteries of the system so that they too may belong to the great order of the *illuminati*.

The great value of symbols and formulas in teaching chemistry is not to be questioned. Their use is essential to the imparting of a quick grasp and a clean mental picture of what takes place. But their abuse is quite possible, and I shall briefly point out some of the dangers which lie in this direction. It must be constantly borne in mind that these formulas do not constitute the science of chemistry, but are merely an abbreviated mode of stating some of the facts, while many do not admit of such concise, graphic representation. So much stress is sometimes laid upon these symbols, and so much store set by their manipulation, that the student may gather the impression that he knows and understands much of the science when he can glibly rattle off a few of them, and he may devote much time to memorizing certain of them which it were far better to spend in an attempt at grasping the great science itself.

It has occurred to me that it might be profitable to point out the following dangers of abuse:

1st. *The Danger of Methodism.* This is a danger common to much of the elementary teaching of the day. We have of late years many schools of methods established all over the country. These have their value in so far as they tell how knowledge may be imparted in an orderly, systematic, methodical manner, but great care must be exercised lest the method should be magnified above the knowledge and the student go away with the empty method alone. I have known such schools where the whole subject was made ridiculous by extended dissertations upon the proper posture of the child in reciting or in drinking water, or some equally subordinate matter where the time at command was too valuable for more than brief mention of such details. And so we can all doubtless recall text-books on chemistry where large space is given to the arrangement, manipulation or completion of formulas and equations. Sometimes they are placed before the pupil like a dissected map or puzzle, shaken together or with some missing member to be supplied, certainly giving him one false idea, namely, that such equations are to be worked out with pencil and paper where the effort should be to impress upon him the knowledge that such equations are legitimate only when they are the result of actual experiments and when proved in every particular by direct trial. Such juggling with formulas may induce a certain ingenuity, but may also be positively harmful so far as the acquiring of true knowledge is concerned.

2d. *The Mathematical Danger.* The effort at placing chemistry upon a mathematical basis, and so making of it a true science, according to the German definition, is a laudable one, but this end is not to be obtained by a multiplication of problems based upon the time-honored rule-of-three and the simple algebraic transformations made use of in chemical problems. Enough of this sort of mathematical work should be given to make clear the great underlying laws of chemistry—the indestructibility of matter, the constancy of proportions, etc. Beyond this harm may be done to some minds not mathematically inclined.

A bright, ingenious mind may revel in some of the abstruse and difficult problems which have been based on this rule-of-three, while other minds may be frightened and confused. There is a temptation to a bright, mathematically inclined teacher to add to these problems and exercises, but I maintain that in such case he is attempting to teach mathematics, and not chemistry.

3d. *The Mechanical Danger.* Many have seen this danger and have given forth no uncertain note of warning against it. In graphically representing formulas, especially those of organic bodies, the mechanical limitations are such that there can be no adequate picture given. Much must be left to the imagination. The effort is only to give an outline or a few points upon which to fix the mental picture. But young minds are at times so hopelessly matter-of-fact, and one of the most difficult of tasks is to transfer the vision of your imagination upon the mental retina of others. In the first place, there is the blackboard with its plain surface and white trails of chalk dust. You are endeavoring to give a picture of some collection of wonderful symmetrical atoms bound together by strange, invisible emanations of force and endowed with marvelous properties and powers. How can you hope to do it with such means as are at your command? How can you devise mechanical means, balls, strings or rubber monstrosities which will properly aid you?

And yet, these mechanical aids are helpful, for mere word painting is far too vague for the purpose. Only beware lest the idea be given that your rubber or glass toys or scratches on the board really look like the incomparable atoms themselves, and that the chemical force displayed between them closely resembles a connecting wire or a bit of glass tubing or a streak of chalk powder.

4th. *The Danger of Idolatry.* By this I mean the placing of the formula upon the pedestal which belongs to the science itself. To my mind, next to the achievement of written language itself, the fully worked-out formula for a complex organic body represents the most wonderful accomplishment of the human mind. It is the result of years of toilsome experiment, of high theorizing and of ingenious logic. It is a building erected by some skilled artificer upon the delicate handiwork of other master-workmen, all resting on the foundation stones of the science laid with infinite care and labor. It is a mighty epic to man's capacity for faithful toil, for self-sacrificing coöperation, for concentration of thought, for ingenuity of eye and hand and brain, and to his love for and deep yearning after the truth.

Yet, with all this granted as true, do not let us fall down before our formula and worship it. It is but the work of our hands after all and *humanum est errare.* The worship of that which may desert us in the time of need is apt to lead to an unfruitful and unhappy skepticism, as the history of our science during the middle decades of this century bears witness. Let us rather be prepared to erect another more beautiful because truer building if the first should be overthrown. It is truth that we seek after, and the building of our hands can never be truth itself, but at best only its fit temple.

I trust that I shall not be misunderstood in what I have said about these dangers. I am not an iconoclast, but wish only to plead for conservatism and moderation.

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THE VETTERN ESCARPMENTS OF SOUTHERN SWEDEN.

To a geologist a fault is always a fault. Whatever its age, whatever the present condition of the land, he reconstructs the dislocation in his mind's eye, and sees the break as vividly as though the action were going on before him. Not so, however, some physiographers. To them a fault is expressive only in its topographic sense; and just in so far as the dislocations can be seen on the surface do many of the students recognize their existence.

On the other hand, the geologist frequently fails to note two points of some importance; at least, he often neglects them in his writings. These are the age of the dislocation, and the form assumed by the land after faulting. While in many cases some attention is paid to these, it is very noticeable that the literature of faulted regions contains little of definite statement concerning them. A good illustration of the physiographic attitude is afforded by a study of the escarpments in southern Sweden which run east from the northern end of Lake Vettern to the Baltic. On the ground, the appearance is of a tolerably steep bluff from higher land on the north down to lower ground on the south. The main escarpment is fairly continuous except near the lake, and is formed of a series of leads and offsets at high angles. The connection between them and the joint systems elaborated by Mr. J. B. Woodworth at once suggests itself, but so far only a general resemblance has been established. The various planes in these examples are more irregular in direction and continuity than in the minute cases which are the basis of Mr. Woodworth's work.

The series may be divided east and west into two parts. That about the lake and for some distance east is characterized by having the angle of the notches face southwest and the sides making the angle concave; the land is higher within the angles, *i. e.*, to the north and east. The rest of the series has angles facing southeast and the sides convex; the land is higher to the north and west. Whether this is due to any known laws cannot be shown at present. One thing is noticeable; the escarpment enters the sea on the east, but dies out on the west. It may be that this is a case of a fault dying out at both ends, and caused by some disturbance at its center; which would probably make a symmetrical figure, not alike on both sides. However, this is mere hypothesis.

To the north of the escarpments the country is a fairly even upland, peculiarly dissected and surmounted by innumerable hills which bear northwest, more westerly than any of the offsets of the escarpments. The drainage is by lakes and small streams. The former are curvilinear, and both take in general the direction of the axes of the hills. All this apparently is due to glacial action, and the same pattern exists over all the country around. In the lowland along the south side of the escarpment series there is a line of drainage from Lake Vettern on the west to the Baltic on the east. It consists of Lakes Boren and Roxen and the estuary Braviken, with a stream connecting them.

The escarpments cannot be due to glacial action, for (1) they are neither in line with the ice motion, as shown by lakes and eskers, nor at right angles to it; (2) in cer-