SCIENCE

NEW YORK, SEPTEMBER 9, 1892.

THE IMPURITY OF ICE.

BY CHARLES PLATT.

WHEN we consider the large quantities of ice used annually in the United States, especially during the summer months, when drinking-water without ice is indeed a rarity, it seems strange that the purity of the ice should so seldom be questioned. On the contrary, while many people will exercise the greatest caution regarding their drinking-water, the origin or source of their ice-supply troubles them not at all. The ice-man brings it, and there is no further need of investigation. This feeling of danger on the one hand, and perfect security on the other, have been, without doubt, due to that peculiar science, "popular chemistry," so widely disseminated in various publications of the land, and especially in the newspapers of the smaller towns with their "patent imsides" bristling with various startling items, often of scientific import.

That this theory, once so popular, of the purification of water by freezing is not in accordance with facts is hardly worth demonstration; we will simply state that while water in its crystalline state should theoretically be nearly pure, still, owing to its peculiar formation in needle-like crystals, considerable foreign matter present in the water in suspension may be, and is, mechanically held within the mass.

On the other hand, of late years there has been a revulsion of public sentiment, and statements have been made denying that water is purified at all by its crystallization. Others have gone so far as to say that certain bacteria thrive best at this low temperature, and, whilst they may be harmlessly disseminated through the water, in the ice they have become concentrated and doubly active. This certainly cannot be sustained by any known facts regarding bacteriological growth, and yet may have some foundation in the fact that in the freezing of still water, such as that of a pond, or small lake, there is a certain concentration of some species of bacteria at the surface of the water, and thus the first inch of ice may contain these in increased numbers as compared with a sample of water from the same lake. As to the increased activity, or indeed as to any vital activity at all of these bacteria, this is another question, and yet to be proven. When this ice is melted, however, and the temperature of the resultant water is raised maybe to the full heat of a summer's day or to that of an over-heated room, then we have another problem, that of possible decomposition and organic change in these organisms that may induce results equal to and exceeding those of the bacteria themselves.

We do not mean to say that all bacteria are necessarily killed outright by the freezing of the water, — the contrary has been proven in many cases, and notably by Dr. Prudden in his well-known experiments with the germs of typhoid fever, — but, in this as in other cases, the germs were found to be present always in decreasing numbers, and in longer or shorter time their vitality is lost altogether. Disease has undoubtedly been produced by use of ice from polluted sources, and this, too, when mere analysis of the ice in comparison with water standards would by no means condemn it. But here let us state that we can by no means use water standards in the analysis of ice. The standards must be much higher, and the analysis must needs be conducted with great care in order to arrive at correct results, even in cases where the ice may be in a manner contaminated.

In regard to the preparation of samples for analysis, Wm. R. Nichols, in his admirable work on "Water Supply," gives a few simple directions that every chemist will do well to follow. "In melting ice for analysis, a fair specimen cake should be selected and broken into fragments in a clean place. The fragments may then be placed in a wide-mouthed bottle covered with a plate of glass, and when enough of the ice has melted to have washed itself, this portion of the water is poured away and the remainder, after melting, subjected to analysis." The same author points out the danger of exposing the melting ice to the air, owing to its liability to attract organisms from the air itself, thus vitiating entirely the results of the analysis.

In the year 1888, the State Board of Health of Massachusetts was directed "to make a special investigation with reference to the pollution of ponds, lakes, streams, and other bodies of water used as ice supplies" in that State. The results of this investigation, which was admirably conducted, are of extreme value; as, by the systematic methods adopted, they were enabled to secure considerable data of general and vital interest to the public as well as to the chemist. Fifty-eight sources of supply were examined, their chemist making, in all, analyses of seventy-six samples of water and two hundred and thirty-six samples of ice. The deductions drawn from their work, stated as concisely as possible, are as follows: In the formation of the ice the color and saline matter of the water is completely removed, and also all but 13 per cent of the other impurities. The same cake of ice will vary greatly as to quality in different parts. The substances in solution are excluded from the ice in much larger proportion than are those in suspension. Of the different kinds of ice, classified as snow ice, bubbly ice, and clear ice, the two former contain a far greater percentage of impurity than the latter, while the upper third of the cake in all cases carries a higher percentage of impurity than the lower two-thirds.

Snow falling upon thin ice will cause it to sink, and finally the snow will become saturated with water; which, in turn freezing, includes within the mass all of its impurities. Then, too, the falling snow has already collected from the air such impurities as were contained, and those also are to be found in the resultant snow ice. The flooding of an ice-field by cutting holes and allowing the water to spread over the ice surface, there to freeze, gives a layer of ice of equal impurity with the water itself; and yet this method of rapidly building up the ice-crop is practised to a great extent throughout the country.

That the bacteria are largely to be found in the surface and snow ice can be seen by the following figures, arrived at by the above mentioned Board of Health. In snow ice was found 81 per cent as much bacteria as in the water itself. The ice as a whole contained but 10 per cent, and the clear ice but 2 per cent. The average results of all the analyses made by the Board of Health show that the total organic impurities of snow ice amount to 69 per cent of those of the water, and the organic impurities of all the ice except snow ice 12 per cent, while the clear ice contains but 6 per cent. The color was entirely removed and the saline matter nearly so.

As mentioned above, the impurity of the snow ice is not due to the water alone, but the air as well must be looked to to account partly for this great increase of organic matter.

These figures might tend to give one a feeling of great security in using ice, as at first thought the decrease of organic matter in clear ice from that originally present in the water itself would seem to argue perfect safety in using ice from any ordinary supply. The Massachusetts Board of Health, however, carefully point out that it is not the number of bacteria alone that is to be considered, but their kind, and they insist that no water-supply that is not fit for drinking purposes should for any reason be used as a supply for ice; and yet how often is this the case; stagnant ponds and even sluggish canals receiving their drainage from many sources being all thought fit to yield their share of the ice harvest.

Fortunately of late years, owing to the repeated failure of the ice-crop, the larger cities in the east are mainly supplied with "artificial" ice. This ice, being formed as it is in the greater number of cases from the regular water-supply of the city, ceases to a large degree to be a source of danger from organic contamination. There have been cases, however, and notably one which fell under my own observation, where an ice company, advertising their ice as made only from pure distilled water, produced daily for some weeks beautiful cakes of crystalline ice, the centre of each cake a rich, dark-brown, and actually giving forth an offensive odor! Some of these samples were sent to me for analysis, and the results were most startling, indicating rather a concentration of impurity, both organic and inorganic, than a distillation or purification. The cause was naturally looked for and found in the stills themselves, which were eventually overhauled and remodeled, with the result that finally a first-class high-grade ice was put on the market.

The necessity for an absolutely wholesome water-supply for the manufacture of ice is at once apparent, as in processes generally in use the entire contents of the water tanks are frozen, and all impurities contained in the water must needs enter the ice. The case referred to was interesting, showing as it did how the color and organic matter had been concentrated in the middle of each cake. The ice forming first at the sides had repelled these impurities until finally, with the freezing of the entire mass, they had of necessity been included.

ELEMENTARY SCIENCE IN THE PUBLIC SCHOOLS.

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MANY years' continuous service as a teacher of young men and women, in a measure, unfits one for acting as an instructor of children. I do not say that a teacher of children requires greater or higher qualifications than a teacher of college students; but the qualifications must be different. One who aspires to be a teacher and leader of students of advanced subjects as taught in colleges and universities ought to have good mental faculties, and these ought to be in a high state of cultivation. With the increasing intricacy and complexity of the studies come increasing difficulties for the students. These difficulties must be recognized and dealt with by the instructor. Hence the successful university teacher must be possessed of teaching powers suited to the minds of students of the advanced branches in which he undertakes instruction. Both the character of the studies and the mental condition of the students of the university differ widely from those of the pupils of the common school. Consequently the teachers of these two classes of pupils must differ widely as to qualifications. Between the primary or common school, on the one hand, and the university, on the other, comes the secondary or high school, which, of necessity, must be supplied with teachers of somewhat different qualifications. The high-school teachers must be adapted to the work of instructing pupils of certain attainments and generally of a certain average age, which stand between the common school and the university. A still more satisfactory grading is effected by classifying all pupils in five divisions, viz., the kindergarten, the common school, the high school, the college, and the university; and in these, especially in the common school, a further grading often proves beneficial. It has many times been found that one who has succeeded well teaching a class in some branch in the common school, has not succeeded as a teacher of a lower class or a higher class in the same branch and in the same school. We all know that a child will voluntarily leave other children that may be older or younger than himself, and seek out those of his own age, or, rather, of his own mental attainments; and, again, on reading a story to a child of nine years no interest is awakened, while on reading the same to another two or three years older or younger the most lively interest and appreciation of it are immediately manifested. The first thing, then, to be considered in the teaching of science is the stage of the development of the faculties of the child. Let this be first diagnosed, and then let no mistake be made in prescribing the kind of material suited to his condition, and the character of the methods of instruction to be employed in his particular case.

To the question, Should science be taught in the public or common schools? I answer in the affirmative. Most decidedly, yes. Which of the sciences? Should it be chemistry, or physics, or zoölogy, or mineralogy, or botany, or physiology, or geology? I answer, all of them as one subject, the study of nature. Specialization, differentiation, or the division of labor, characterizes civilization. It is forced upon us in the higher studies. This is simply a matter of necessity, due to the vastness of the fields of higher learning, the shortness of life, and the limits of the human mind. But, it is possible to specialize only in the maturity of manhood and womanhood. It is not possible in childhood. The youthful mind is not capable of such work. The young mind is not able to fix attention or concentrate thought upon a subject, and particularly if the subject be studied in an isolated and disconnected manner. Add to this a method that is both systematic and abstract and the avenues to learning are completely closed. In very early years, say before the age of eleven or twelve, the average child cannot readily or profitably study anything in an isolated, a systematic, and an abstract manner, and he can do it but very feebly at this age. The study of a subject systematically by classification, the study of the abstract, and the cultivation of the reasoning faculty should not be attempted early. Nature rebels against it. It is the faculty of perception which appears first. This is the faculty which should receive the attention of the teacher of children. To the cultivation of observation, expression, and memory, along with the full physical development of the child, all the best energies of the teacher should be given. It is not a question, then, of dividing and classifying the natural and physical sciences, and choosing one or more of them to be placed on the curriculum of schools. This is necessary and proper in the later years of the high-school courses, and in the higher institutions, but not in the common school, or to any great extent in the lower classes of the high school. System, method, and classification in study are exceedingly important for matured persons; but, they do not belong to early life. As soon as the mind is prepared to undertake such work, it should be begun; and it should be increased very slowly, gradually, and almost imperceptibly. I repeat it, common-school pupils ought not to be taught zoölogy as a distinct science, nor botany, nor physics, nor geology as such. All systems of classification, even to the division of these sciences, are artificial. Chemistry, physics, mineralogy, botany, zoölogy, physiology, and geology should not be separated. These sciences come naturally together; and, therefore, they are most readily understood and remembered when studied in this way. Let the child see the fish swim in the water, the bird fly through the air, the duck swim and sail on the pond, the river erode its banks, the waves beat and grind the pebbles against one another on the beach. Let him be led to use his senses in observing the soil, clay, sand, gravel, grasses, trees, flowers, butterflies, beetles, worms, crops, streams, hills, ravines, bees, squirrels, ants, crickets, birds, snow, rain, stones, rocks, and fossils, just as they occur in nature. In any case, even to adult persons, the associations are of vital significance. Many a time it happens that a mineral sample, a bit of rock, or a fossil, by itself is of but little use in helping us to understand some question of moment. Again, an extract from a book may be unintelligible or ambiguous. But, in the one instance, permit us to see the associated minerals and rocks in position, and, in the other, to read the context, and what a flood of light is let in upon us! The relations that objects of the three kingdoms of nature bear towards one another are of the utmost importance. But, in addition to the importance of the associations and relations, the ease with which children are enabled to comprehend the characteristic structure, habits, and uses of anything when studied as it occurs in nature, is something the teacher and parent cannot afford to ignore. An old-fashioned method of teaching orthography consisted in compelling the pupil to learn a column or a page of isolated words chosen with reference to the number of syllables they contained. Some of these words were extremely rare; many of them would not be