SCIENCE:

PUBLISHED BY N. D. C. HODGES, 874 BROADWAY, NEW YORK.

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RECENT PROGRESS IN AMERICAN HORTICULTURE.[1]

BY L. H. BAILEY, ITHACA, N.Y.

YOU have asked me to say something about recent progress in horticulture. I am at a loss to know how you want the subject treated. The subject is a large one, and can be approached in many ways. It is by no means admitted that there is any recent progress. There is a large class of our horticultural public which disparages these modern times as in no way so good as those of several or many years ago. These men are mostly gardeners who were apprenticed in their youth. There is another class which decries the introduction of new varieties of plants, thinking these novelties to be unreliable and deceitful. There are others who are content with the older things and who have never had occasion to ask if there has been any progress in recent years. Others have looked for progress, but have not found it. A professor of horticulture told me a few days ago that nothing new nor interesting seems to be transpiring in the horticultural world. Some people even deny outright that any progress is making at the present time. On the other hand, there are some, perhaps the minority, who contend that they see great advancement. Perhaps these are mostly young men. Then there are the catalogues with their fascinating impossibilities, pregnant with the glory that is to come. Between all these diversities, where is the young man to stand who loves plants and sunshine and is yet ambitious? Is there any progress in horticulture? If not, it is dead, uninspiring. We cannot live on the past, good as it is; we must draw our inspiration from the future. This subject is of vital personal interest to me; it must be so to you.

I cannot forego the satisfaction of saying at the outset, that some of this supposed stagnation must be due to blindness on the part of the observer. The apprenticed gardener underwent in his youth the stupendous misfortune of having learned the art and science of horticulture. The apprentice system, in itself, does not often educate a man; that is, it does not make him a student. It teaches him to base the whole art upon rule, personal experience and "authority;" it is apt to make him a narrow man, and he may not readily assimilate novel methods. Those who have looked for progress and have not found it, may have looked in the wrong place. It is possible that they do not understand very clearly just what progress is. Those who are simply indifferent exert little influence upon our inquiry and may be omitted. Those who see progress upon all sides may be over-sanguine. Perhaps they project something of their own passion into their statements. And the catalogues, being for the most part editorial rather than horticultural productions, may be liberally discounted as evidence. It is apparent, therefore, that we must make an independent inquiry if we are to answer our own question. Several considerations incline me to believe that progress is not only making, but that it is making very rapidly. And I may say here that I care little for any facts or illustrations of progress merely as facts. There must be some law, some tendency, some profound movement underlying it all, and this we must discover. I shall not attempt, therefore, to indicate how great the progress has been in any definite time, but endeavor to ascertain if there is progression which gains impetus with the years.

1. *There is a progressive variation in plants.* Horticulture is the science of cultivation of plants. The plant is the beginning and the end. For the plant we till the soil, build green-houses, and transact the business of the garden. All progress, therefore, rests upon the possibility of securing better varieties, those possessing greater intrinsic merit in themselves or better adaptations to certain purposes or regions. In other words, all progress rests upon the fact that evolution is still operative, that garden plants, like wild animals and plants, are more or less constantly undergoing modification. American horticulture may be said to have begun with the opening of the century. It was in 1806 that Bernard M'Mahon wrote his "American Gardener's Calendar." This work contains a catalogue of 3,700 "species and varieties of the most valuable and curious plants hitherto discovered." Among the cultivated varieties of fruits and vegetables, the present reader will see few familiar names. He will observe among the fruits, however, some American types, showing that even at that date American pomology had begun to diverge from the English and French which gave it birth. This is especially true of the apples, for of the fifty-nine kinds in the catalogue about 66 per cent are of American origin. Several nurseries were established in the next thirty years and fresh importations of European varieties were made, so that when Downing, in 1845, described the 190 apples known to be growing in this country, American varieties had fallen to 52 per cent. In 1872, however, when almost 2,000 varieties were described in Downing's second revision, the American kinds had risen to 65 or more per cent, or to about the proportion which they occupied at the opening of the century. At the present time, the per cent of varieties of American origin is much higher, and if we omit from our calculations the obsolete varieties, we find that over 80 per cent of the apples actually cultivated in the older apple regions at the present time are of American origin. The percentage of native varieties, in other words, has risen from nothing to 80 per cent since the apple settlement of the country, and at least once during this time the native productions have recovered from an overwhelming onslaught of foreigners. Except in the cold north and north-west where the apple industry is now experiencing an immigration not unlike that which befell the older States early in the century, few people would think of importing varieties of apples with the expectation that they would prove to be a commercial success in America. Other plants have shown most astounding development. In 1889, 39 varieties of chrysanthemums were introduced in North America; in 1890, 57 varieties; and in 1891, 121 varieties. The chrysanthemum is now the princess of flowers, yet in 1806 M'Mahon barely mentioned it, and there were no named varieties. All this is evidence of the greatest and most substantial progress, and much of it is recent; and there is every reason to believe that this rapid adaptation of plants to new conditions is still in progress in all cultivated species. In fact, the initial and conspicuous stage of such adaptation is just now taking place in the Russian apples in America, in which the American seedlings are even now gaining a greater prominence than some of their parents. Both the parent stock and the seedling brood are radical and progressive departures of recent date. The same modification to suit American environments is seen in every plant which has been cultivated here for a score or more of years. The mulberries are striking examples, for our fruit-bearing varieties are not only different from those of Europe, whence they came, but many of them belong to a species which in Europe is not esteemed for fruit. The European varieties of almonds are now being superceded in California by native seedlings which are said to be much better adapted to our Pacific climate than their recent progenitors. These facts of rapid adaptation are everywhere so patent upon reflection that I need not consider them further at this time. They

[1] Read before the Agricultural and Experimental Union of Ontario, at the Ontario Agricultural College, Guelph, Dec. 23, 1892.

are indisputable evidence that there is permanent contemporaneous progress, and upon them alone I am willing to rest my whole argument.

There is another feature of this contemporaneous variation which must be considered at this point,—the great increase in numbers of varieties. This increase is in part simply an accumulation of the varieties of many years, so that our manuals are apt to contain descriptions of more varieties than are actually cultivated at the time. But much of this increase is an actual multiplication of varieties. That is, there are more varieties of all plants in cultivation now than at any previous time. M'Mahon mentions six beets as grown at his time; in 1889, there were 42 kinds. Then there were 14 cabbages, now there are over 100. Then there were 16 lettuces against about 120 now. He mentions 59 apples, now there are about 2,500 described in this country. He mentions 40 pears, against 1,000 now. There were something over 450 species of plants native to the United States mentioned by M'Mahon, now there are over 2,000 in cultivation. These figures are average examples of the marvellous increase in varieties during the century. I may be met here with the technical objection that M'Mahon did not make a complete catalogue of the plants of his time. This may be true, but it was meant to be practically complete, and it is much the fullest of any early list. Gardening occupied such a limited area a century ago that it could not have been a burdensome task to collect very nearly all the varieties in existence; and any omissions are undoubtedly much overbalanced by the shortcomings of the contemporaneous figures which I have given you. It is certainly true that during the nineteenth century varieties of all the leading species of cultivated plants have multiplied in this country from 200 per cent to 1,000 per cent. This variation still continues, and the sum of novelties of any year probably exceeds that of the preceding year. Every generation sees, for the most part, a new type of plants.

But I suppose that these statements as to the increase of varieties will be accepted without further proof. The question which you all desire to ask me is whether all this increase represents progress. Many poor varieties have been introduced, beyond a doubt, but I am convinced that the general tendency is decidedly progressive. You may cite me the fact that we have not improved upon the Rhode Island Greening and Fall Pippin apples, the Montmorenci cherry, the Green Gage plum, and other varieties which were in cultivation at the opening of the century, as proof of a contrary conviction; but I shall answer that we now have a score of apples as good as the Greening, although we may have none better. This habit of saying that we have not improved upon certain old plants is really a fallacy, for the reference is always made to quality of fruit alone; and, furthermore, the test of progress is not the supplanting of a good variety, but the origination of varieties which shall meet new demands. The more numerous and diverse the varieties of any plant, the more successful will be its cultivation over a wide area, because the greatest number of different conditions — as soils, climates, and uses — will be satisfactorily met. If we had at present only the apples which were grown in M'Mahon's time, apple culture in the prairie States, in our bleak North-West, and even in some of the apple sections of Ontario, would be impossible. We are constantly extending the borders of the cultivation of all fruits by means of these new varieties. The horticultural settlement of our great West and of the cold North is one of the wonders of the time. We should not ask ourselves of a new variety if it is better in all respects than other varieties, but if it will fill some specific need more satisfactorily. If a variety does better than all other varieties in one locality alone, for one specific purpose, it is not a failure, and it represents progress. Every peculiar or isolated region tends to develop a horticulture of its own, but this is possible only with a corresponding initial variation in plants. No doubt many of our discarded varieties failed to find the place or conditions in which they would have succeeded. We should not look upon adverse reports upon the novelties as necessarily denunciatory; they may only indicate that in some places or for some purposes the variety in question is unsatisfactory. I must also call your attention to the fact that while the areas of cultivation have greatly widened in recent years because of the evolution of adaptive varieties, the economic uses of the plants have increased in like ratio. We now have varieties of fruits which are specifically adapted to the making of dried fruit, to canning, to enduring long journeys, and the like; and flowers which meet specific demands in decoration or other uses. The period of maturation of varieties has extended greatly in both directions, so that fruits and flowers are now in season much longer than formerly. The gist of the whole matter is simply this, that our horticultural limits and products have greatly broadened in very recent times by reason of the great increase in number and diversity of varieties; and this leads us to expect that still other wants will be met in like manner, and that the uttermost habitable parts of the country will develop a special horticulture

2. *There is a constant augmentation in new specific types of plants, both from our native flora and by importation from without.* I suppose that there is no parallel to the marvellous evolution of native fruits in America. Within a century we have procured the grapes, cranberries, the most popular gooseberries, some of the mulberries, the raspberries and blackberries, the pecans and some of the chestnuts, from our wild species. Perhaps the strawberries can be traced to the same source. There are many men still living who remember when there was no commercial cultivation of these fruits. Here is progress enough for one century; yet an overwhelming host of new types is coming upon us. I sometimes think that the improved native plants are coming forward so rapidly that we do not properly appreciate them. Witness the perplexing horde of native plums, the varieties even now reaching nearly 200, which are destined to occupy a much larger area of North America than the European plum now occupies. New species of grapes are now coming into cultivation. The dewberries, juneberry, Crandall currant type, buffalo berry, wild apples, and more than a score of lesser worthies, are now spreading into our gardens. Many of these things will be among the staples a hundred years to come. One hundred and eighty-five species of native plants, some for fruit but mostly for ornament, were introduced into commerce last year; and the number of plants native to North America north of Mexico which have come into cultivation is 2,416. Under the stimulus of new conditions, some of these species will vary into hundreds, perhaps thousands, of new forms, and our horticulture will become the richest in the world. It is a privilege to live when great movements are conceived and new agencies first lend themselves to the dominion of man.

Many species have come to us from many parts of the world throughout the century, but the immigration still continues, and perhaps is greater now than at any previous time. It is well nigh impossible to chronicle the new types of ornamental plants which have come to America during the last two decades. Consider the overwhelming introduction of species of orchids alone. Even the wholly new types of fruits are many. Over twenty-five species of edible plants have come to America comparatively recently from Japan alone, and some of these species are already very important. Two of them, the Japanese persimmons and the Japanese plums, are most signal additions, probably exceeding in value any other introductions of species not heretofore in the country, made during the last quarter-century. During the years 1889, 1890, and 1891, some 380 species of plants not in commercial cultivation here were introduced into North America, partly from abroad and partly from our own flora. In the year 1891 alone 219 distinct species were introduced.

Valuable as these new types are in themselves, all experience teaches that we are to expect better things from their cultivated and variable progeny. We can, therefore, scarcely conceive what riches the future will bring.

3. *There is great progress in methods of caring for plants.* The manner of cultivating and caring for plants has changed much during recent years. It is doubtful if all this change represents actual progress in methods, but it indicates inquiry and growth, and it must eventually bring us to the ideal treatment of plants. Some of the change is simply a see-saw from one method to another, according as our knowledge seems to point more strongly in one direction than another. In one decade we may think lime to be an indispensable fertilizer, and in the next it may be discarded; yet we may eventually find that both positions are un-

tenable. Yet there has been a decided uplift in methods of simple tillage and preparation of land and the science of fertilizing the soil; and, moreover, the application of this knowledge is widespread where it was once local or rare. And the application of machinery and mechanical devices to almost every horticultural labor cannot have escaped the attention of the most careless observer.

Among specific horticultural industries, the recent evolution of the glass-house has been remarkable. In 1806 the green-house was still a place in which to keep plants green, and M'Mahon felt obliged to disapprove of living rooms over it to keep the roof from freezing, because they are "not only an additional and unnecessary expense, but they give the building a heavy appearance." The first American green-house, with a wooden roof and heavy sides, was built in 1764. Glass-houses increased in numbers very slowly until the middle of this century, and they can only now be said to be popular. Twenty years ago a glass-house was a luxury or an enterprise suited only to large concerns, and the management of it was to most intelligent people an impenetrable mystery. At the present time, even the humblest gardener, if he is thrifty, can afford a green-house. In fact, the glass-house is rapidly coming to be an indispensable adjunct to nearly all kinds of progressive gardening. The secret of this increasing popularity of the glass-house is the simplicity of construction of the modern building. Large glass, low, straight roofs, light frames, simple foundations, small wrought-iron pipes, portable automatic heaters — these are the innovations which have given the green-house a greater popularity and practicability in America than anywhere else in the world. Yet many of these features would have been heresies when Leuchars wrote his excellent book in 1850.

The simplification and popularization of the glass-house has simplified the management of plants in them. Even laymen are now taking to green-house plant growing, and many of them achieve most gratifying results. The first days of the commercial forcing of plants are still within the memory of many of this audience; and it is only within the present decade that great attention has been given in this country to the forcing of tomatoes, cucumbers, carnations, and many other plants. The business is yet in its infancy. The green-house has also exerted a marked influence upon the plants which are grown in them. There has now appeared a list of varieties of various plants which are especially adapted to the purposes of forcing; and this phenomenon is probably the most important and cogent known proof of contemporaneous evolution.

If one were asked off-hand what is the most conspicuous recent advancement in horticulture, he would undoubtedly cite the advent of the sprays for destroying insects and fungi. These are not only eminently effective, but they were perfected at a time when dismay had overtaken very many of our horticulturists, and they have inspired new hope everywhere, and have stimulated the planting of fruit and ornamentals. I fancy that the future historian will find that the advent of the spray in the latter part of this century marked an important epoch in agricultural pursuits. Yet this epoch is not disconnected from the era before it. It is but a natural outcome or consequence of the rapid increase of insect and fungous enemies, which increase, in turn, is induced by the many disturbing influences of cultivation itself. When we devise effective means of checking the incursions of our foes, therefore, we are only keeping pace with the initial progress fostered by the origination of new varieties and the quickening commercial life of our time. Yet the era of spraying is none the less a mark of great achievement, and we have not yet seen the good of which it will ultimately prove to be capable. But a greater achievement than this must be made before we shall have reached the ideal and inevitable method of combatting external pests: we must learn to so control natural agencies that one will counteract another. Nature keeps all her forces and agencies in comparative equilibrium by pitting one against another in the remorseless struggle for existence. The introduction of insect parasites and predaceans, entomogenous fungi, colonization of insectivorous birds, and the use of strategy in cultivation and in the selection of immune species and varieties and the planning of rotations and companionships of plants, will eventually be so skilfully managed that most of our enemies will be kept under measurable control. A short rotation is now known to be the best means of combatting wire-worms and several other pests. The first great success in this direction in America is the introduction of the Australian vedalia, or lady-bug, to devour the most pestiferous of the orange-tree scales on the Pacific coast. This experiment is pregnant of greater and more abiding results than all the achievements of the sprays. But in your generation and mine, men must shoulder their squirt-guns as our ancestors shouldered their muskets, and see only the promise of the time when they shall be beaten into pruning-hooks and plough shares and there shall come the place of a silent warfare!

4. *There is great progress in the methods of handling and preserving horticultural products.* I need not tell the older men in this audience that there has been progress in the methods of handling fruits. When they were boys, apples and even peaches were taken to market loose in a wagon-box. We have all seen the development of the special-package industry, beginning first with rough bushel baskets or rude crates, then a better made and smaller package which was to be returned to the consignor, and finally the trim and tasty gift packages of the present day. I am sorry to say that some regions have not yet reached this latter stage of development, but their failure to do so only makes the contrast stronger of those who have reached it. Quick transportation and methods of refrigeration have tied the ends of the earth together. Apples in quantity are carried 14,000 miles from Tasmania to England, and in 1890 they reached the San Francisco markets to compete with the fruits of the Pacific coast. From a small beginning in 1845, the exportation of American apples to England and Scotland began to assume commercial importance from 1875 to 1880, until nearly a million and a half barrels have been exported in a single season. It is said that the first bananas were brought to the United States in 1804, and the first full cargo in 1830. Now from eight to ten million bunches arrive annually. The Canary Islands are now shipping tomatoes to London, and the United States will soon be doing the same. Watermelons will follow. California now unloads her green produce in the same market. Even pears are exported from America to Belgium, disputing the old saw that it is unwise to carry coals to Newcastle. The world is our market. But this result may have been achieved with some detriment to home markets and transportation, which have been in some measure overlooked and neglected; but this evil must correct itself in the long run.

Perhaps we owe to a Frenchman the first distinct exposition, some eighty years ago, of a process of preserving perishable articles in hermetically sealed cans; but the process first gained prominence in the United States, and it became known as canning. In 1825, James Monroe signed patents to Thomas Kensett and Ezra Daggett to cover an improvement in the art of preserving, although Kensett appears to have practised his method somewhat extensively as early as 1819. Isaac Winslow of Maine is supposed to have been the pioneer in canning sweet-corn, in 1842. About 1847 the canning industry began to attract general attention, and in that year the tomato was first canned. The exodus to California in 1849 stimulated the industry by creating a demand for unperishable eatables in compact compass. North America now leads the world in the extent, variety, and excellence of its canned products, and much of the material is the product of orchards and gardens. In 1891, the sweet-corn pack of the United States and Canada was 2,799,453 24-can cases, and the tomato pack was 3,405,365 cases! Over 20,000 canning factories give employment, it is said, to about one million persons during the canning season. The rise of the evaporated fruit industry is not less remarkable in its way than that of the canning industry.

There are other marvels of progress in methods of caring for horticultural products, but these examples sufficiently illustrate my position. I am aware that all these things are features of commerce and manufacture rather than of horticulture, but they are responsible for much of the phenomenal extension of horticultural interests in recent years. They have also exerted a powerful influence upon the plants which we cultivate, and varieties have appeared which are particularly adapted to long carriage

and to canning and evaporating. The vegetable kingdom is everywhere responsive to the needs of man.

5. *There is a corresponding evolution in the horticulturist.* The rapidity with which education and general intelligence have spread in recent years is patent to every one. The rural classes have risen with the rest, but among the agricultural pursuits horticulture has probably shown the greatest advance in this respect. The horticulturist grows a great variety of products, many of which are perishable, and all of which demand expedition, neatness, and care in marketing. And these many and various crops bring in a multitude of perplexities which not only demand a ready knowledge for their control, but which are important educators in themselves. The horticulturist lives nearer the markets and the villages than the general farmer, as a rule, and he is more in touch with the world. Downing rejoiced in 1852 that there were "at least a dozen societies in different parts of the Union devoted to the improvement of gardening, and to the dissemination of information on the subject." Since that time a dozen national horticultural societies of various kinds have come into prosperous existence, and there are over fifty societies representing States, provinces, or important geographical districts, while the number of minor societies runs into the hundreds. Over fifty States, Territories, and Provinces have established agricultural schools and experiment stations, all supported by popular sentiment. The derision of "book farming" is well nigh forgotten. Subjects which a few years ago were thought to be "theoretical" and irrelevant are now matters of common conversation. In short, a new type of man is coming onto the farms. This uplift in the common understanding of the science of cultivation, and of the methods of crossing and of skilful selection, is exerting a powerful accelerating influence upon the variation of cultivated plants. But the most important and abiding evolution is that of the man himself; and I expect that the rising intellectual status will ultimately lead people to the farm rather than away from it. We are just now living in a time of conspicuous artificialism; but the farm must be tilled and it must be inviting. When agriculture cannot pay, something is wrong with the times.

These, then, are the chief lines of progress in horticulture, and they are all still operative and capable of indefinite growth. The achievement of a generation has been phenomenal. The prospect is inspiring to both the cultivator and the student.

THE IMPORTANCE OF "NEXT-TO-NOTHING" IN CHEMISTRY.

BY W. H. PENDLEBURY, M.A. (OXON), SCIENCE LECTURER OF DOVER COLLEGE, ENGLAND.

In the year 1888 the President of the British Association for the Advancement of Science took for the subject of his inaugural address "The Importance of 'Next-to Nothing.'" As a matter of course, Sir Frederick Bramwell treated his subject with his usual wit and ability, and pointed out the influence of small things on the advancement of his particular branch of science—engineering. It might, however, be well to carry the idea still further and to collect together, as far as is possible in a short paper, the facts that have come to light showing the influence of traces of a foreign substance upon chemical change. Some of the facts are almost paradoxical. Take the case of an ordinary coal fire, which was probably one of the first objects which aroused the interest and curiosity of mankind and awakened the instinct of scientific investigation. It is needless to refer to the erroneous views held on the subject of combustion, but it may just be mentioned that the discovery of oxygen seemed to settle the matter and to establish on a firm basis the whole theory of combustion. In the years 1887 and 1888[1] the experiments of Mr. H B. Baker made it quite clear, however, that the presence of aqueous vapor had a great deal more to do with combustion and hence the burning of an ordinary coal fire than we were aware of. He showed that if oxygen be rendered perfectly dry, by leaving it for some time in contact with phosphorus pentoxide, combustion is rendered impossible in such gas. Carbon, sulphur, or phosphorus may be strongly heated in an atmosphere of perfectly dry oxygen without taking fire, and, in fact, the sulphur and phosphorus may be distilled in it. The presence of a trace of moisture at once brings about the combustion. The writer has seen Mr. Baker distil phosphorus in an atmosphere of oxygen and then, whilst the phosphorus was still melted, admit a bubble of oxygen which has been standing over water and at once the phosphorus burst into flame. Hence it is highly probable that the ordinary phenomena of combustion could not take place in our atmosphere if there was not aqueous vapor also present. This would furnish another reason against the probability of the moon's being inhabited, as owing to the absence of aqueous vapor fire would not be possible there.

The great influence of a trace of moisture in bringing about chemical changes in which of itself it is not directly concerned, if we may so express it, is evident from many other observations. Wanklyn discovered that dry chlorine will not combine with dry metallic sodium, but that a trace of moisture will start the reaction. Dixon found that a mixture of carbon monoxide and dry oxygen will not be exploded by the electric spark, but that the presence of a trace of moisture will bring about a silent combination under the influence of the spark, whilst if the gases are moist, the explosion will take place readily.

Again, it has been recently observed that ethylene and oxygen, when perfectly dry, do not explode when acted upon by the electric spark, but the presence of moisture acts in this case as in the former.

Again, carbon dioxide is not absorbed by dry lime. Sulphuretted hydrogen in the dry condition does not tarnish dry silver. Dry iodine does not decompose dry sulphuretted hydrogen.

We may take another example of the influence of next-to-nothing of an impurity in bringing about a change in which its influence had been till lately little regarded. The experiments of Mr. V. H. Veley[2], of Oxford University Museum, on the action of nitric acid on various metals has conclusively shown that the violent action which nitric acid has upon many metals is due to the presence of a trace of nitrous acid in the nitric. He has kept spheres of copper in the strongest nitric acid (freed from the presence of nitrous acid) for some time without any reaction occurring, but when once a trace of nitrous acid or of any nitrite was added, the copper was at once dissolved. The same kind of result was observed when mercury, silver, or bismuth were exchanged for the copper. It was found that from 1 to 2 parts of nitrous acid in 10,000 of the nitric were sufficient to set up the reaction.

Mr. Cross found that jute fibre, when treated with sulphuric acid, is simply hydrolysed. If, however, ordinary nitric acid, containing a trace of nitrous acid, be allowed to act on the jute, a considerable amount of chemical action takes place, and amongst other substances, like urea, which either prevents the formation of nitrous acid or decomposes it as quickly as it is formed, the action of nitric acid on jute is strictly comparable with that of sulphuric acid, simple hydrolysis taking place.

It is highly probable that many of the changes in organic chemistry, generally ascribed to the action of nitric acid alone, are due to the presence of traces of nitrous acid.

It is well known that pure zinc will not dissolve in pure hydrochloric acid or pure sulphuric acid, but the presence of a trace of a metallic salt sets up the reaction very readily.

If we take another branch of chemistry—metallurgical chemistry—the immense importance of the presence or absence of a trace of a foreign substance in a metal is readily seen, since it produces an immediate effect on the hardness or tenacity of the metal, and so may destroy its usefulness in commerce. Take the case of copper. Professor Roberts-Austen states in his Cantor lectures that a cable made of the pure copper of to-day will carry twice as many messages as a similar cable made of the less pure copper of 35 years ago, when the importance of the purity of copper was not so well understood, and he quotes a saying of Sir Wm. Thomson's that the presence of $\frac{1}{10}$ per cent of bismuth in the copper of a cable would entirely destroy its commercial success by reducing its conductivity. Sir Hussey Vivian has

[1] Preceedings of the Royal Society, vol 45, and Phil. Trans., 1889

[2] Philosophical Transactions, 1891.