Influence of Chemistry on Civilization[1]

Lecture I—The Chemist at the Breakfast Table

James C. Irvine

The University of St. Andrews, Scotland

MY THEME is "Chemistry and World Progress;" in other words, it is an attempt to give, in popular fashion, a perspective view of what the science of chemistry has done to influence human activities and to trace the connection between chemistry and world conditions.

It is an unusual theme, for statesmanship, whether applied to the problems of a single town or expanded to the relationship between one country and another, rests almost exclusively on the study of political philosophy built up on experience dating back to Plato and beyond. Within this philosophy there is included also the consideration of social and national economics, and the equipment seems adequate enough without including the highly specialized knowledge embraced by the chemistry of today. If we think over the situation a little more closely, however, at once we must pause and wonder if the broad principles from which we have emerged all too slowly during the past two thousand years and the economics which has come into existence in the past one hundred and fifty years are sufficient when we face the conditions of today.

How can these conditions be appreciated if we ignore the factors which, almost hourly, are changing the face of the world, creating and recreating entirely different economic situations?

In legislating on national and international questions it is not enough to make provision only for the conditions of today; it is necessary to take thought of the tomorrow, and it is my belief that we do not sufficiently take into account the fact that science—and of all the sciences none more than chemistry—is a potent force which has now assumed a magnitude capable of changing the whole aspect of human affairs.

This is a statement made by a chemist. It must be justified and in doing so I shall make no assumptions but construct the situation from the beginning.

Is the world actually progressing and, whether the answer be in the affirmative or not, has chemistry played any recognizable part in affecting the world movements and conditions? It will simplify argument on these points if I at once rank myself with the optimists and claim that world progress is definitely toward a goal of greater human happiness. Perhaps we can gain a rough and ready measure of the direction of world progress if we test it in terms of the definition of personal success which I heard given by the late Bonar Law. "Success is a measure," he said, "of a man's power to make other people happy." It is a good definition, and we need not restrict it to the success of individuals but can apply it to the success of a nation.

How far is the world becoming a happier place and what has chemistry done in the past, either to add to that happiness or to detract from it? These are the questions immediately before us. If we can answer them, we shall be in a better position to consider what chemistry may do for the future.

The specialization to which I have devoted my life is something which seems to lead its devotees back to the cloistered cell rather than forward to the striving world of industry and of politics, and, although in these days no cloistered cell remains in Britain, scientific specialists become, all too often, outcasts from the realities of life. There is, too, a memory, which haunts me, of words spoken by my friend, J. M. Barrie: "In these days the only man who has anything to say is the scientist, and he doesn't know how to say it."

My life is spent for the most part in the medieval cathedral city of St. Andrews where, more than five hundred years ago, Scotland's oldest university was founded. This life has become curiously intermingled with scientific and administrative work on behalf of the British Government, so that it has become resolved into two distinct phases, one reflective and academic, the other intensely active and, in consequence, less introspective. Reflection on this dual existence leaves not the slightest doubt in my mind that it is from the college window one can best view the movements which characterize our time. We live in an age of movements, many of them transient, more of them trivial, some powerfully charged with revolt, yet still a few which are the expression of man's striving for the good. Thus, it is a thought often in my mind that it should surely be possible, from a quiet university center, to exercise some measure of control over these popular movements. I use the word "control," but my meaning is better expressed by "direction," for it is by direction rather than by coercion that lasting progress is made.

These circumstances of quiet detachment from the world surround us now, and the task before me is to discuss not only in how far the subject of chemistry has played a part in influencing world progress, but also to set up the ideal that, so far as it is in our power, we shall strive to use the forces inherent in chemistry for man's spiritual and intellectual happiness.

So much for the problem and its goal; I turn now to the method of approach. It is not a particularly easy matter to speak to an audience which may include both the learned professor and the energetic man of business, for what pleases the one may well weary and distress the other. In fact, only two opinions are held regarding such addresses, and you may hear them expressed as the audience disperses. One is—"there was nothing new in that," and the other, equally discouraging,—"I didn't understand a single word." I am confronted now with the dangers of Scylla and Charybdis but, if shipwrecked I must be, I prefer to meet disaster on the rock of over-simplicity.

When we think of chemistry and world progress, our minds travel almost automatically to the factory, and are disposed to dwell on the chemists' industrial achievements for we are confronted with them on every hand. Even the noisy traffic of the city is a continual reminder that raw materials come from the uttermost parts of the earth to the chemical factories, there to be transformed into the so-called "fine chemicals;" the skyline is separated with chimney stalks, the very atmosphere of many of our towns is charged with chemical fumes. My theme in this first address is, however, simpler. I wish to deal with small things, rather than with great, and to conjure up a picture showing how chemistry permeates into every nook and cranny of our complex civilization. Let us halt for a moment and consider where we stand—how in the simple and insignificant details which go

[1] First of a series of lectures presented at the Institute of Chemistry of the American Chemical Society, Evanston, Ill., July 24, 1928.

to make up the routine of daily life, in things which through their familiarity are ignored, we are today reaping a rich harvest which the chemist has sown.

The Chemist at the Breakfast Table

As a means of emphasizing some small fraction of what we owe to chemistry, I have adopted as my introductory subject the consideration of how far this science has entered into the beginning of the day's work when the average man prepares for the fray by the consumption of his breakfast. It is a humanistic theme, domestic yet international, and if I may borrow a title from the genial American essayist who philosophized on men and things at the daily board, I may proceed to talk of "The Chemist at the Breakfast Table."

Let us draw on our imagination, for my table is unadorned with the customary breakfast fare or with the familiar trappings of the lecture-theater. Let us borrow one other thing, the fantastic conception of Swift in which he created the race of the Struldbrugs, men doomed to immortality who saw the events of centuries pass before them as personal experiences. Let us construct for ourselves a Struldbrug chemist who has been himself responsible for the succession of chemical discoveries which, in varied and well-nigh unrecognizable form, find a place on the breakfast table before him.

We shall imagine him—despite his honorable and successful career—still young, eager and observant, but in a reflective reminiscent mood nevertheless. For these reasons, I dare say, we must consider him to be a bachelor, or at least one who breakfasts in solitary state; in any case a wise man.

His Linen Tablecloth

It is a cheerful morning, his mind is undisturbed and alert as he takes his place, but at once a shadow crosses his face as his eyes fall on the snowy expanse of the linen tablecloth before him. It recalls a problem to which he has devoted many years of fruitless effort, and the memory is not a pleasant one. Here is the best of fabrics, woven from a fiber which fascinates all who have worked with it, but still separated from the flax straw by what is practically the original method of primitive man. Think of it. We manufacture today on a scale undreamed of by our grandfathers, but the first step in linen manufacture remains the same as in Biblical times. Every stage in the process, save the first, has been improved out of recognition, but we still "ret" flax by spreading on grass or by immersion in ponds or rivers—using, no doubt, Nature's method—in this case a tedious, precarious, and uncertain process. Now, our chemist naturally joined in the many efforts which have been made to elucidate the chemistry of the retting process, and thereby to standardize it scientifically. Theoretically, it was surely a simple matter to remove the pectins and resins which attach the bast fibers to the straw, but high-pressure heating, steam distillation, treatment with mild alkalies, or even with bacteria were alike tried in vain and one after another his promising patents were taken out only to be abandoned. Here is certainly a problem which has beaten the chemist so far, but his labors have at least paved the way for the ultimate solution. His fellow-workers, the plant physiologist and the bacteriologist, will profit from the conclusion to which all chemical evidence points—that flax-retting is a process involving the action of enzymes on colloidal hemicelluloses or pectins and that successful retting means the accurate adjustment of the hydrogen-ion concentration. He wonders for a moment how far the great linen research associations which have come into being in recent years have penetrated this ancient mysterious process, and he ponders over the new economic problems created by his recent discovery of rayon.

But if our hungry chemist has achieved only a partial success in the preparation of the linen fabric, he can at all events regard with satisfaction the smooth whiteness of the finished product. How his mind must bridge the gap of nearly one hundred and forty years to the early days of chemical bleaching and, more particularly, to that happy discovery of bleaching powder which brought to Scotland a new industry and the alkali trade along with it.

The Morning Paper

The contemplation of the tablecloth awakens a train of memories which go right back to the gentle Scheele and includes, as links in the chain, such names as Berthollet and those enterprising Scotsmen James Watt and the Tennants—all of them, of course, old friends of our chemist, who is anxious, however, to get a start made with his breakfast. The solemn ritual of a glance at the daily newspaper claims his attention with the first course. It evokes profound satisfaction, for he well remembers the time when it was not a daily production, and cost a sum for which, until recently, he could obtain a bound reprint of last year's novel. Of the many factors which have contributed to this end, the one which most appeals to our chemist is his own work on paper pulp, and how cellulose from the most diverse sources can be worked up to the milky suspension which flows over the frames in hundreds of paper mills all over the country. He is willing to admit that mechanical pulp has its limitations, but it makes cheap paper, and by thus helping to render literature of all kinds available and to distribute the news of the world to the humblest of its citizens, the chemist can make a proud claim.

His Oatmeal Porridge

In this country you cannot estimate the importance of the morning newspaper or of the daily sustained interest in the affairs of state which it makes possible because you have never been deprived of it. In Britain we know now what it means, for we had that experience two years ago in those critical days of the general strike and our day-dreaming reflective philosopher is no doubt alive to it all. Were he not a Scot—and for my purpose he must be one—he might almost be pardoned if he were to continue gazing at the unfolded news sheet while wrapped in contemplation; but, being both Scottish and hungry, he commences on the national dish, which, with all deference to the opinion of Robert Burns, I maintain is oatmeal porridge. Several things, however, distract his attention at once, although these cannot interfere with the true enjoyment of the healthy Scot with well-made porridge before him. The milk he uses brings to memory a long struggle when the analytical processes of the chemist were in their infancy and were being brought to bear on the question of food adulteration. It recalls those years of patient work which have resulted in one of the greatest steps in modern times—the recognition that Public Health is one of the foundation stones of national prosperity. And it is to the chemist that most of the honor is due for preserving the purity and safety of our foodstuffs. There was a day when the Biblical warning, "There is death in the pot," might well have been uttered at nearly every breakfast table. The milk before our friend was at one time watered, deprived of its cream, mixed with starch and calcium sulfate, not to mention chalk, or polluted with so-called preservatives.

Now these adulterants are fairly easily determined, but before the analytical results have any meaning, think of the labor involved in standardizing the composition of average milk: the thousands of analyses, the investigation of the fatty constituents, the mineral salts and carbohydrates; of the elaboration of quantitative methods for the estimation of each of these, before the chemist goes the length of detecting accidental and added impurities. Consider, moreover, the bacteriological extension which has taken place in milk and water analysis, and you will realize some of the feelings which pass through the mind of our chemist as he pours the milk over his porridge with the assurance that, thanks to his own efforts, what he is consuming is the honest unadulterated product of the cow.

As for the cereal itself, an old anxiety recurs to our friend as he thinks of the great problem it suggests—the artificial production of nitrates. He well remembers the time when the scientists of his earlier days were quite unacquainted with the element nitrogen, far less with the chemistry of its circulation in nature. It was his friend Rutherford, was it not, who first isolated the element by shaking air, in which animals had breathed, with limewater? Then followed the recognition of combined nitrogen in the cereal foodstuffs, and from that it seems to him only a step to the use of nitrates as fertilizers for enriching cultivated ground. He remembers disapproving of the use of Chile saltpeter for this purpose, on the score that it was a pity to employ such a convenient source of nitric acid, but reports of the extent of the Chile beds were so reassuring that he withdrew his objection. Then, in time, Sir William Crookes informed him that, in his presidential address to the British Association, he intended to call attention to the alarming drain which had been made on the world's supply of nitrates. Our chemist then learned that matters were indeed serious, that the output from the Chile beds in 1860 was 68,500 tons, and this figure rose by leaps and bounds to the appalling maximum of 1,500,000 tons; how any estimate of the extent of the Chile deposits must reveal a limiting date beyond which, until recently, we dared not let our minds travel. He knows that agriculture and a hundred varied industries were wholly and implicitly dependent upon suffices of nitrate furnished by a little strip of land in a South American republic. He smiles grimly as he thinks of the world's indifference to its needs. He has often puzzled over the problem of oxidizing free nitrogen—surely when there are 33,800 tons of the element over every acre of land, the problem of the world's supply of nitrates should be readily solved. It has been fully solved, at first by merely tentative steps to compensate for this unavoidable drain on a store of material which Nature replaces only slowly, and finally, by the development of great processes which saved the world, yet made a world war possible.

And here, he reflects, is still another example of small things becoming great in the hands of the chemist. He knew Cavendish well, and was present, over one hundred years ago, in that dingy laboratory when the Cambridge professor demonstrated privately to his friends, that oxides of nitrogen are formed when electric sparks are passed through dry air. Then, as now, political turmoil ruled men's thoughts and the observation passed unnoticed, but in the passage of time the Struldbrug scientist has seen too many reactions once carried out in test tube or retort and now performed in caldrons and furnaces, to be surprised at the development of the Cavendish experiment. In place of the tiny spark, a sheet of flaming electric discharge, the small glass globe replaced by a furnace through each unit of which 3000 cubic feet of air per minute are drawn, and giving an output of thousands of tons of calcium nitrate per annum. He well remembers his satisfaction when, some twenty years ago, he learned from his friend Von Brunck that the Badische Anilin und Soda Fabrik had taken up the matter and were prepared to run the early Norwegian process on an extended scale. Here notice that our Struldbrug chemist is cosmopolitan in his friendships, and, appreciating the Teutonic virtue of thoroughness, was relieved to know that Germany was serious in her efforts to produce artificial nitric acid. How simple and innocent he was, he reflects, for, in his interest for humanity he had overlooked that other use of nitric acid in the manufacture of the high explosives of war.

He saw nothing but the world's good in the exploitation of Haber's heroic efforts to synthesize ammonia or in Ostwald's schemes to oxidize ammonia catalytically. Often he had spent a holiday in Leipzig, or at the picturesque house in East Prussia to which the great physical chemist retired in the autumn, and there held high discussions of philosophy, experimental psychology, and politics.

Only after the war interrupted this friendship did the outcome of Ostwald's latest work become apparent.

Cut off from Chile niter, Germany made her own synthetic nitric acid, and thus was able to prolong the war far beyond the calculated limit of her resources. Our chemist finds comfort in the fact, however, that Crookes' gloomy vision of a wheat famine has been dissipated, and that, by one of the most remarkable developments in the world's history, the production of artificial nitrates has become part of the standard manufacturing operations of both the Old and New Worlds. This achievement does not surprise him, for he has seen too many cases of the chemical curiosity of today becoming the imperative necessity of tomorrow, and he believes that the simple preliminary experiments he witnessed last century will help to provide bread, and, incidentally, porridge for the next. He feels confident that the world will not starve through lack of cereals, but he is glad Crookes published that pamphlet on the wheat problem, for occasionally it is a good thing to let the world know where it stands and how narrow is the line which separates us from disaster.

His Spoon and Plate

These considerations have flashed through his mind in less time than it takes to report his thoughts. The empty plate lies before him, the empty spoon is in his hand. No longer, he thinks, may men be sharply divided into two social classes according as to whether they were born with a silver or a horn spoon in the mouth. The hundred and one alloys he has discovered and the trick of electroplating have combined to provide all with silver spoons, distinguishable only by the hall mark. Even the very plate before him has cost him some trouble, for he worked long and hard at complex silicates in order to restore at least some of the lost arts of the potter; more recently, he had to turn to the question again in search of a leadless glaze and, having found it, he now awaits legislation to enforce the use of his discovery.

Legislation, he reflects, helping himself to the fish, has never been sufficiently influenced by the work of the chemist. True, he has no inclination for the rough and tumble game of politics. A sense of exactitude, and a love of truth and honor it may be, have kept him from the hustings and platform, but he feels it has not been for the good of his subject or for the good of the world. Commissions on industrial questions, on education, and on one hundred other problems, on which his opinion should be necessary, have too often been formed without his help, although many instances could be chosen to show how far-seeing the chemist may be in practical legislation.

The Fish Course

The fish course has, in fact, all but disappeared ere memory turns again into the main course of the reflections which the meal evokes. There is much of his past work connected with this item of his fare. The march of civilization has made necessary the preservation of fish during its transportation over long distances. The chain of communication from the traveler to the breakfast table is a long and complicated one, and the many problems involved have been solved only through the coöperation of the physiologist, the bacteriologist, the chemist, and the engineer.

His Cup of Tea

An appalling list of recollections assails his brain—now, I am afraid no longer clear, but somewhat bewildered by the flood of remembrance—when he turns to the last phase of the meal. He chips the top off the egg, butters his roll, and pours out a cup of tea. The tea is well made. It ought to be good, for it is made with the water which his own analyses have certified to be sound, and his experiments have shown that the infusion contains nothing deleterious. He certainly has more faith in the purity of tea than in that of coffee. One of the old notebooks on the shelf proclaims that in coffee he has at various times detected chicory, roast wheat, beans, baked liver, sawdust, tan, or even Venetian red—truly a formidable list.

Not by any means does he maintain that tea is always unsophisticated—far from it. He has detected in it the leaves of nearly every plant which grows and he has found it doctored, moreover, with such additions as Prussian blue and lead chromate, but the food and drugs acts have driven home a lesson which has been learned most effectively, and prosecutions for adulterating tea are now rare, for the very good reason that there can be no two opinions as to when adulteration has taken place, and convictions are fairly easily obtained.

Sugar for His Tea

But tea needs sugar, and as he holds the lump in the tongs he gazes at it and wonders whether its sweetness was gathered in the sunny Indies or in the more prosaic European plains. His weekly bills describe it as "cane sugar," but he has his doubts about its claim to the title. Whatever its source he is content, for it is indisputably pure through his own work. An alluring substance it is to him, for it is to this he turns when he can spare time to take an afternoon at pure research. How fascinating are these curving chains of carbon atoms, and how subtly are the two constituents—the glucose and fructose—bound in the molecule. Many a time he has tried to synthesize cane sugar, and what matter if he has failed in this, for has he not, step by step, elaborated and improved the two great manufacturing processes which compete today on terms of deadly rivalry. He has not much to learn in a process where 98 per cent of the theoretical yield is obtained on a scale where thousands of tons of material are manipulated.

But what a task it has been. The careful study of climatic conditions on the yield of sugar in the sugar cane was a trifle compared with the obstacles encountered with the beet. The difficulties in keeping the molasses down, in getting the sugar to crystallize in presence of dextrins, in excluding invert sugar and deliquescent traces of impurity. It was one long fight, but he triumphed only to find that he had created new economic difficulties which were almost international.

How he regrets that he has not been more of a politician—more like that well-known chemist who led the European sugar world and bound the manufacturers to wage the great war of the sugar bounties. Thus, a few years ago we had the Brussels Sugar Convention, and with it, Europe mightily disturbed by Russia's proposal to send a few thousand tons of sugar westwards. Questions were asked in the British Parliament which no one could answer, for if our chemist is not much of a politician, most politicians are totally ignorant of chemistry.

His Bread and Butter

The meal is not making much progress just at present, for the attention of the individual at the table has come to rest on the bread and butter on his plate. Some years ago he became involved in the "standard bread" craze, and actually wrote a number of letters to the newspapers, and carried out some analyses, on behalf of the movement. The fact is, however, that he didn't like the new bread much, even though it did contain the whole of the semolina, etc., and he was thoroughly tired of war bread, when stern necessity made some of us careful in our milling. He certainly prefers white bread, now that he can get it, and if alum is excluded from it, but he does hope that the flour has not been bleached with nitrogen peroxide, or doctored with the so-called "improvers." He is strong on this point, and recently drew public attention to it in a powerful article contributed to the British press.

Meanwhile he is finishing up with bread and butter—at least, he hopes it is butter, for the butter-substitute business is his own invention, and he is not quite sure how it is going to develop from the point of view of public health. You see he believes in hormones, vitamins, and food accessories, and thus is somewhat alarmed at the extensive use of artificial foods and the spread of scurvy and rickets.

He hopes for the best, however, and at least he has got margarine manufacture to work on sound lines, to select pure materials, and to control the process bacteriologically. During the war many new factories were built under his direction, and he is proud of them. Every sample is now sterilized; the flavors introduced are natural flavors, produced in thermostatic chambers by the action of twelve distinct families of lactic acid bacillus—factories to show the world and producing butter substitutes superior far, from every point of view, to many so-called butters, of which one in ten is adulterated clumsily with foreign fats, sometimes to the extent of 90 per cent. Moreover, he takes pride in the fact that, even before the war, he had added to the national larder by applying catalytic methods to the hydrogenation of oils to convert them into edible fats. His excellent monograph on industrial catalysis is well known, but perhaps not the extent to which these hardened oils are used in supplementing natural fats as the basis of margarine. Providence saw to it that this research was complete, and its results in working operation before the day of want came to the world.

Fuels and the Coal Question

The meal is over at last. He pushes his chair aside and reaches over to the mantelpiece where rests his trusty pipe, which he fills with the loving care born of long experience. He has a busy day ahead of him, but there is still time for a smoke in front of the fire. The burning coals conjure up a picture of one of the struggles which still lies before him—the investigation of new fuels—for he agrees that it is time we counted the cost of the wholesale tapping of our coal resources. He is engaged with the task now.

Then there are the questions of coal-mine explosions to be settled, smoke prevention, the purification of the air of towns, and a vast number of other inquiries which must wait a little. Of one thing he is determined—that if there is any more juggling with the price of rubber he will look over his notes on methyl isoprene and see what can be done in matching the chemical laboratory against the stock exchange.

Chemical Warfare and Peace

He was a member of the Armistice Commission, and saw with his own eyes what Germany had accomplished in her hour of need. The thought of his trip to the banks of the Rhine brings back once more the memory of the war and the time he spent as a scientific soldier. He does not like to think of his experience in this field, for war in all its forms is hateful to him, and chemical warfare most of all, yet he recognizes its grim necessity and accepts it.

The discarded newspaper has told him of the great proposal that the nations of the earth should join in a pact of peace and he realizes that this may well mean the first step in disarmament, but it is the last step which puzzles him. Forts may be demolished, warships may be sunk, armies may be disbanded, but the chemical factory must always remain a source of potential destruction. How can the nations protect themselves against the possibility that a rebel nation may indulge in a mad renewal of this abuse of scientific discovery? How are chemical industries to be preserved and kept alive, yet kept in the paths of peace? He can provide no answer and he shudders with disquietude.

His Morning Pipe

These are questions for the future; the present holds the enjoyment of the morning pipe. What a boon to a poor smoker, he thinks, is that simple estimation of occluded moisture in vegetable tissue which he worked out some time ago, thus preventing more than a reasonable amount of fraud in the tobacco trade. Above all, what an improvement the safety match is over its many predecessors. Ah, those days, not so very remote, of the flint and steel, and what a comfort it was to use the first chlorate matches, although they had to be dipped into fuming sulfuric acid which often spilled in the waistcoat pocket. What a splendid year 1827 was. Berthelot was born that year, just about the time when John Walker patented his friction matches. How they were prized, even although one hundred cost one dollar. It needed courage in these days to ask a man on the street for a match. No wonder the manufacture of matches grew into a huge industry; yet what sufferings were borne by the workmen until a grizzly specimen in the shape of a phossy-jaw on the table of the House of Commons convinced parliamentary opinion that the safety match must be accepted.

Final Reflections

As the smoke curls upwards our chemist reflects on the changes, most of them blessings, which his craft has brought to life and to the home. But he also thinks of the thousands of breakfasts being consumed on every hand by those who are blind to the great things which masquerade as the trivialities of daily experience—either blind, or frankly indifferent. Yet they would be the first to call out in dismay if the clock of time were to be put back and the less comfortable conditions of a hundred years ago restored, even for one morning.

Then comes a last comforting reflection as he knocks the ashes out of his pipe. His thoughts have wended their way across the Atlantic and are arrested at the meeting of the Institute of Chemistry. Here in being is a movement which he realizes is full of meaning for the world. That men should dedicate some part of their time seriously to consider those forces, some apparent and others obscure, which work continuously either to bind together or to disrupt the nations of the earth, is to him, in his wisdom, a worthy vocation. But his comfort comes chiefly from the fact that this year the program of study included a due recognition of the part his favorate science of chemistry plays in all branches of politics ranging from the domestic to the international. He is by no means satisfied with the choice of the lecturer on chemistry and world progress, but at least, he believes that such a subject cannot lose its appeal even when presented falteringly and inadequately, yet he shakes his head doubtfully and wishes he himself had the chance to deliver his own views.

At this stage, I begin to quarrel with my imaginary chemist; he has become too personal, and so I proceed to destroy him. Yet, I am grateful to him, for this insight into his mind has convinced me that there is a connection between chemistry and world progress, and that we do not need to look beyond the simplest elements of life to find the evidence. Not at the breakfast table only, but throughout life, man is in touch with the scientific past as well as with the present and future. By the cultivation of this remembrance and by individual effort one may acquire the spirit expressed by Berthelot, that science is the road to national progress and that scientific training is merely the finger post which points the way. We see the long line of the chemists stretching back into the mists of antiquity, their figures becoming ever more shadowy, and now realize, more fully than ever before, what we owe to them. Among the reflections evoked, none is stronger and none should be more reverently valued by the disciple of science than that which reminds us of the debt we bear to those who have gone before us.

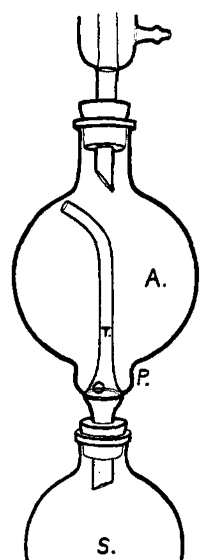
To the deep and difficult foundations which they laid, to their patient and sometimes thankless and unrewarded labor, we owe our present points of vantage, our present ambitious intellectual structures. "They have labored and we have entered into their labors."

A Large-Capacity Laboratory Extractor[1]

F. E. Holmes

The Procter & Gamble Company, Ivorydale, Ohio

The extraction apparatus illustrated was designed to meet a need for apparatus to prepare fat-free constituents for rations for small experimental animals in somewhat larger amounts than could be done with the Soxhlet extractor. It is more easily assembled and of much more rugged construction than the large extractors with which we were familiar. A further advantage is that the tube which delivers the vaporized solvent is kept warm in the center of the extraction flask; consequently less solvent condenses and runs back. When alcohol or benzene is the solvent satisfactory results can be obtained by immersing the lower flask to the neck in a water bath kept vigorously boiling by steam, thus avoiding the possibility of the solvent catching fire, and minimizing the amount of attention required in carrying out the extraction.



The small bulb, P, is packed with cotton to act as a filter and the material to be extracted is placed above it in A. The flask is then connected to S containing the solvent, and to a reflux condenser. The vaporized solvent is delivered through T. The condensed solvent returns through a small hole in T near the bottom of P.

Two of the above extractors were blown using a 1-liter Pyrex flask for one and a 2-liter flask for the other. Pyrex tubing of about 11 mm. diameter inside below the seal and 5 to 7 mm. diameter above was used for T. Two pieces of Pyrex tubing of the proper size were fused end to end and the joint blown out a little beyond the diameter of the larger one. The small hole for the return of liquid solvent was blown just above this in the small tube. A bulb was blown to form P on the bottom of the flask and an opening blown out in the end. The tube was then fused in place in this opening.

[1] Received May 14, 1928.