elongated particles; they are anomalous in all their physical properties and are polydisperse. No true crystals have been prepared from these, but dilute solutions show anisotropy of flow strongly, and concentrated solutions are liquid crystalline. X-ray studies of solutions of tobacco mosaic virus have demonstrated a regularity of structure previously unsuspected in fluids, for the particles are arranged equidistant from one another so that the available space is filled uniformly. When mixed with their antisera, these rod-shaped virus particles precipitate almost immediately, giving bulky, fluffy precipitates resembling those produced by bacterial flagellar antigens.

Solutions of bushy stunt and tobacco necrosis viruses behave very differently and show none of the anomalous properties characteristic of elongated particles. By suitable treatments they can be induced to crystallize in forms characteristic of the individual virus. When mixed with their antisera, they precipitate more slowly than the rod-shaped viruses and, as might be expected with spherical particles, pack more closely to give dense, granular precipitates resembling those produced by somatic antigens.

What is the relationship between these isolated nucleoproteins, which in laboratory work behave much like preparations of other proteins, and the viruses as they occur in the plant ? There is enough evidence now to show that these proteins are the viruses in the sense that they can initiate infection. Nevertheless, it would be premature to assume that, while active in the host plant, the viruses are chemically so simple as analysis of the purified preparations suggests. During the course of isolation, many materials are discarded as impurities; most of these are certainly constituents of the normal host, but some may well be specific products of virus activity. Any such are clearly not essential for infectivity; but if the virus were organized cellularly, they would be retained within a cell wall and would be accepted as integral parts of the virus, which would immediately look a much more complex body than does our naked protein particle.

In the absence of specific tests for any product of virus activity, we have no positive evidence for their occurrence in plants, but evidence from various sources suggests that purification may be altering the viruses. Purified preparations of tobacco mosaic virus, for example, contain particles about 15 mμ wide but varying in length from less than 100 mμ to more than 1,000 mμ. There is nothing to show that the greatly elongated particles occur in the plant, and much to suggest that they are produced by the linear aggregation of small particles during the course of preparation. By taking suitable precautions, solutions of tobacco mosaic virus can be made that show little or no anisotropy of flow and behave serologically more like somatic antigens; but these are unstable and readily change into anisotropic solutions with serological behaviour characteristic of flagellar antigens. This change seems to be connected with the removal of other material from the small nucleoprotein particles, which then join together end-to-end. The change in size and shape may explain the failure to produce true crystals of this virus *in vitro*, though they occur abundantly in infected plants.

We know also that the purified virus readily combines with other proteins such as trypsin and ribonuclease, and that these can be removed again without affecting infectivity. May not similar combinations occur within the host, and be responsible for converting this nucleoprotein into a functioning system capable of multiplication and of the activities of which the results are so obvious ?

In addition to the changes produced by purification, there is other evidence that virus does occur in the plant in forms with different properties from those of the purified nucleoproteins. Until recently, all laboratory work on plant viruses was done with the sap that is expressed from macerated infected leaves. This was thought to contain all the virus in the plant, for washing the fibrous residues gives little extra virus. However, these residues actually contain as much virus as does the sap; but normally this is insoluble, probably because it is combined with other substances, and special treatments are needed to get it into solution. It is possible that this insoluble virus is the biologically active system, whereas that free in the sap may be merely excess virus functioning as a mobile source of infection for other cells. We know so little about the multiplication of viruses, and of their activities within the host, that at present we must suspend judgment. But it is probably safest to regard the nucleoproteins as the chemical minima—equivalent to reproductive organs or embryonic viruses—which develop into working entities only when placed in an environment containing the materials or enzyme systems they lack in their purified state.

CHEMISTRY AT THE OLDER UNIVERSITIES OF BRITAIN DURING THE EIGHTEENTH CENTURY

By ARCHIBALD CLOW
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IN 1814 Sir John Sinclair, president of the Board of Agriculture, wrote :

"At present there are a greater number of intelligent practical chemists in Scotland, in proportion to the population, than perhaps in any other country in the world" (J. Sinclair, "General Report", App. 2, p. 307).

In the light of this rather startling assertion, it is instructive to analyse the development of chemistry in the universities of Scotland during the preceding hundred years, and to compare it with developments farther south. In Great Britain there are five universities to consider: in England, Oxford and Cambridge; in Scotland, Edinburgh, Glasgow and Aberdeen. There was no profession of chemistry at St. Andrews until at a later date.

While alchemy yet held the field, the universities of Scotland remained aloof from the flux of gold and elixir making, but at the end of the seventeenth century the Surgeons' Incorporation in Edinburgh established a laboratory where apprentice apothecaries received a chemical training. The instigator of this pioneer development was Alexander Monteith. He was thus a contemporary of Sir Isaac Newton (1642–1727), who in Cambridge was still studying Boyle's method of gold-making during 1690–93, perhaps not without hope of practical application, since within a few years he was appointed Warden of the Mint.

In the early years of the eighteenth century, the Town Council of Edinburgh decided to appoint a professor of chemistry in the Town's College, and in 1713 James Crawford was selected to fill the chair. Crawford did not achieve European reputation, but he was a product of the great Boerhaave school at Leyden, and his appointment to Edinburgh is significant. It inseminated Scotland with the finest seed of Continental chemistry, and it gave professorial status to a teacher of chemistry in advance of most other countries. The only other university with a like claim is Oxford. On cursory examination it appears that, as a centre of chemical activity, Oxford has indeed a better claim. This arises in the main from its association with the alchemistic Roger Bacon, but even R. T. Gunther points out that "it is a moot point whether Roger Bacon really made much impression on his contemporaries; if any, it was evanescent; and in the succeeding centuries Oxford savants continued to wander in a maze of arbitrary figments and partial inductions, in which experimental science found no place". (R. T. Gunther, "Early Science in Oxford", 7.)

In the middle of the seventeenth century, we find that for a time Oxford did indeed give hospitality to an evacuee, Robert Boyle (1627–91), one of the greatest of contemporary thinkers. For fourteen years from 1654 Boyle was at Oxford. While there, he became the centre of a small coterie of intellectuals who doubtless helped to bring about what J. U. Nef calls the first English industrial revolution. Boyle's influence was rather that of a patron experimentalist than a teacher; but he was responsible for introducing to Oxford its first regular teacher of practical chemistry. It was a long time, however, before the teaching of chemistry became continuous. In compensation for the paucity of chemical instruction, an important contribution to technics made by an Oxford B.C.L. may be mentioned.

"The mystery of salt-glazed stone ware was discovered by the ingenious John Dwight of Christ Church, who set up a manufacture at Fulham. . . . When and where John Dwight became acquainted with this use of salt is not known but in 1671 he took out a patent for his process, and in the same year the first specimens of salt-glazed ware were being manufactured at Fulham. Soon after 1688 similar ware was being produced at Burslem by the Dutchman Elers, and in 1700 in Nottingham". (R. T. Gunther, "Early Science in Oxford", 27.)

Oxford suffered from its proximity to London, and the removal of Boyle (as well as of other intellectuals which followed the more settled conditions of state established in 1660) did irreparable damage to its scientific life. The only man of science worthy of the name who remained was John Mayow, whose "De sal-nitro et spiritu nitro-aereo" heralded the later discovery of oxygen. But Mayow too left Oxford in 1675, and died in 1678.

"Thus closed the brief life of the greatest chemist whom Oxford has ever produced. His works, a century in advance of the times, were unappreciated during his life and were soon neglected, buried and forgotten under a thick pall woven in Germany by Stahl, out of a warp of genuine facts and a weft of false hypotheses". (R. T. Gunther, "Early Science in Oxford, 32.)

By one of the unfortunate accidents to which collegiate monasticisms are prone, Mayow was not an associate of Boyle; indeed they seem to have been mutually unaware of each other's work, and Mayow's contributions remained hidden for many years. Yet his manipulative skill substantiates his claim to be considered one of the founders of pneumatic chemistry. Thus while Oxford may claim an earlier contribution of chemistry applied to manufactures than can Edinburgh, its periods of seventeenth century brilliance were sporadic and contrast markedly with the continuity of chemical teaching undertaken at Edinburgh.

So far as continuity is concerned, albeit it was mediocre, Cambridge fared better than Oxford. In the early years of the eighteenth century, that is, contemporary with Crawford's professorship at Edinburgh, the title of honorary professor of chemistry at Cambridge was conferred on one J. F. Vagani (*c.* 1650–1713), a native of Verona. Of Vagani we know little, but he was probably the first chemist there to throw off the alchemical tradition. From records of purchases made to illustrate his lectures, it is highly probable that they were biased towards pharmaceutical ends. It is interesting to note that one of Vagani's students was Stephen Hales (1677–1761), whose researches on the chemical reactions of plants laid the foundation on which Francis Home of Edinburgh was able to build his "Principles of Vegetation".

Vagani was followed by John Waller, who lectured until 1718, and Waller in turn by John Mickleburgh, who brings us up to 1741.

By this time great changes had taken place in Scotland. In 1724, four fellows of the Royal College of Physicians announced that they had purchased a house in Edinburgh for a chemical laboratory, and indicated that they proposed to lecture extramurally on chemistry and *materia medica*. Every one of them had studied at Leyden under the celebrated Boerhaave, and thus went to Edinburgh with the finest training that could be obtained at the time. They were Drs. John Rutherford (1695–1779), Andrew Plummer (*d.* 1756), John Innes (*d.* 1733) and Andrew St. Clair. After extra-mural teaching for a few years, they insinuated themselves into the University, which for a time boasted four "professors of chemistry". None of the quartet made revolutionary contributions to the advance of chemical theory or practice—Rutherford's son discovered nitrogen, it is true—but their significance in the history of technology and science lies not in their own contribution but in the pioneer foundations established by their students. Plummer particularly was the mentor of several founders of chemical industry, as well as of two of the greatest academic chemists Scotland, or for that matter any country, has produced, namely, William Cullen (1710–90) and Joseph Black (1728–99).

Of Plummer's industrialist pupils, John Roebuck (1718–94) is the most important. The manufacture of sulphuric acid was first carried out in England on what may be called an industrial scale when Dr. John Roebuck, in company with Samuel Garbett (1717–1805), established his works at Steelhouse Lane, Birmingham, in 1746. They set up a second works at Prestonpans in 1749, and with the profits gained in these very successful enterprises Roebuck went on to found Carron Iron Works in 1760, thus opening up for the first time the carboniferous deposits of central Scotland.

The establishment of sulphuric acid manufacture on an industrial scale in both England and Scotland by Roebuck and Garbett—and it must be remembered that Roebuck's interest in chemistry was derived from Plummer's teaching at Edinburgh—is of signal importance, since it almost immediately brought about a revolution in the art of bleaching by the application of the researches of another Edinburgh professor, Francis Home (1719–1813), professor of *materia medica* in the University from 1768. The introduction of sulphuric acid at this early stage in the industrialization of bleaching was indeed a milestone in the long chain of contributions made by Scottish chemists to industrial development.

About the same time as Roebuck settled at Prestonpans, another student of Plummer began to engage in chemical manufacture. He was no other than the celebrated Scottish geologist, James Hutton (1726–97). Beckmann in his "History of Inventions and Discoveries" states:

"If I am not mistaken, the first real manufactories of sal ammoniac were established in Scotland; and the oldest of these, perhaps, was that erected by Dovin and Hutton at Edinburgh in 1756* and which, like many in England, manufactures this salt on a large scale" (4, 383).

Soot was the raw material used, and they continued to use it for many years until they began to buy crude sa ammoniac from a tar works that had been established in the interim by Lord Dundonald at Culross.

All this has to be set against "the mystery of salt-glazed stone ware", contributed by Oxford.

From Edinburgh the teaching of chemistry spread to the University of Glasgow. William Cullen (1710–90), having studied arts at Glasgow and medicine under Plummer at Edinburgh, was appointed a teacher of medicine at Glasgow in 1746. Stimulated by Plummer's teaching, he developed a dominant interest in chemistry, and in 1747 induced the University to establish the teaching of *Chemie*. In the same year, Cullen himself, and a John Carrick, were appointed lecturers in chemistry. Carrick however died in 1750, and Cullen was left to continue the course on his own.

Cullen's outlook on chemistry was severely practical, as has been that of all great Scottish chemists. At the beginning of his second course he printed and distributed "The Plan of a Course of Chemical Lectures and Experiments directed chiefly to the Improvement of Arts and Manufactures". He clearly recognized the importance of scientific chemistry and its application to industrial and agricultural development. While in Glasgow he devoted a considerable part of his time to industrial problems of the time, particularly to those subjects of which industry demanded a chemical investigation, for example, salt-boiling, bleaching, and alkali supply.

"He was a great master of the scientific branches of husbandry; a consummate botanist, and possessed a correct taste in the fine arts. In the year 1758, after finishing off chemistry, he delivered to a number of particular friends, and favourite pupils, more lectures on the subject of agriculture. In these few lectures, he, for the first time, laid open the true principle concerning the nature of soils, and the operations of manures." (A. Bower, "History of the University of Edinburgh", 2, 392.)

In 1751, Cullen was appointed professor of medicine and lecturer in chemistry at Glasgow, which posts he held until 1755, when he was appointed colleague and successor to Plummer, and moved to Edinburgh. In Glasgow he was succeeded by Joseph Black (1728–99), who followed him both at Glasgow (1756) and later at Edinburgh (1766).

* The correct date is a good deal earlier than that given by Beckmann.

If we compare the number of students reading chemistry at Edinburgh and at Cambridge at this period, it is likely that Edinburgh will be found to have the smaller number, but an expansion took place almost immediately. In the light of these figures we can sympathize with Davies, who wrote to Stephen Hales in 1759 lamenting that at Cambridge,

"Anatomy, botany, chemistry, and pharmacy have been but occasionally taught; when some person of superior talents has stayed up and has honoured the University by his first display of them, before his passage into the world". (R. Davies to S. Hales, 1759.)

In Scotland at this date Cullen was teaching in Edinburgh and Black in Glasgow.

In 1766 Black went to Edinburgh to succeed Cullen, who had been translated to another chair, and for thirty years he occupied the chair of chemistry during one of the great formative periods through which chemistry has gone, both in expansion on the theoretical side and in its application to industry. So great were Black's contributions to fundamental chemistry that one is apt to forget that he also kept in close touch with contemporary industrial developments, especially in a consultative capacity, and through personal contact with friends like Roebuck and Hutton. Of particular interest are his attempts, in collaboration with Roebuck and James Watt, to synthesize alkali; his connexion with the initial stages of Lord Dundonald's Tar Works. Problems concerning Cort's process for the production of malleable iron were referred to him. He advised on pottery problems. Specimens of ore and water from the lead mines at Wanlockhead and Leadhills were sent to him for analysis. His opinion was sought by the committee investigating Scottish distillery. He devised methods for the chemical assay of kelp.

What of chemistry in the 'older' universities? Mickleburgh, who had been appointed to Cambridge shortly before Cullen, went to Glasgow, gave way to John Hadley (1731–64), and he in turn to Richard Watson (1737–1816), afterwards Bishop of Llandaff, who was appointed professor of chemistry at Cambridge in 1764. At the time of his appointment it was said of Watson that "he knew nothing at all of chemistry, had never read a syllable on the subject, nor seen a single experiment in it". In two years the illustrious Black was to succeed Cullen at Edinburgh. Small wonder that the evolution of chemical science in the two countries was so different. Yet Watson was no idle churchman. He took his new appointment very seriously, and has related how at one period his conscience forced him to burn his chemical writings lest he be lost to the church altogether. Among other activities, he took steps to make the occupancy of the chemical chair more secure by persuading the Crown to make an annual grant of £100. It should be noted that initially there was no stipend attached to the chair that Cullen and Black occupied. They were remunerated by their students' fees and the takings of private medical practice.

Despite his inauspicious start, Watson was the first Cambridge chemist to evince any interest in the advance of industry based on exact chemistry knowledge which was taking place in various parts of the country. His "Essays", published in 1784–88, contain useful pictures of various industries, particularly on coal, lead and zinc, and his researches on charcoal production for gunpowder by closed distillation of wood are known to have saved the Government large sums of money.

Black's influence was transmitted throughout the civilized world by the appointment of his students to influential positions in the academic and industrial world. Black was to Edinburgh what Boerhaave was to Leyden. Not only did his students, Robison, Irvine, Hope, Cleghorn, and Thomson, follow him in the lectureship at Glasgow and chair at Edinburgh, but also others founded chemical schools throughout the country and abroad. Ogilvie went to Aberdeen, Thomas Garnett to the Andersonian University of Glasgow, J. Morgan and B. Rush established the teaching of chemistry at Philadelphia. Wm. Henry, the Manchester chemist, studied under him, as did Sir Humphry Davy's brother John. Humphry regretted that it had not been his own good fortune to study under Black. But of particular importance here is that two of his students had a vitalizing effect on the lethargic schools at Cambridge and Oxford. Let us follow the evolution of Oxford after the death of Mayow referred to above.

Oxford chemistry did not recover easily from the loss of Mayow, although one might have expected the Ashmolean foundation to bring about a revival. A number of chemists followed in the laboratory established by Elias Ashmole (Robert Plot, Edward Hannes, John Freind, Richard Frewin), but none of them succeeded in establishing any sustained teaching or research school.

"The reason for this sterility was not far to seek. The Oxford contemporaries of Newton had not the enquiring mind; the most brilliant of her sons devoted their genius to other ends and developed their talents in other places; those who stayed behind were content to accept the statements of others without testing them for themselves, and to pass on to their students information acquired at second-hand. The business of teaching was set higher than the duty of research." (R. T. Gunther, "Early Science in Oxford", 53.)

Ashmole's inadequate foundation was, from the chemical point of view, a failure, and chemistry continued to lag behind other expanding sciences. No university professor was appointed, with the result that students who wanted to acquire some familiarity with the science had no one better to instruct them than the college fireman.

The only interesting outcome of the Ashmolean period is the association of John Wall (1708–76) of Merton with the foundation of the Worcester Porcelain Company (1751); but such a connexion cannot be considered adequate to compensate for the new low level to which Oxford intellectual life sank in the earlier part of the eighteenth century. Wall's connexion with Oxford was strengthened through his son, Martin Wall (1747–1824), delivering a course of lectures there from 1781 in the capacity of 'public reader in chemistry'.

The next development in the chemical history of Oxford was of great importance (corresponding as it did with the appointment of Smithson Tennant to Cambridge): it was the appointment of Thomas Beddoes (1760–1808), also a student of Joseph Black's at Edinburgh, to be reader in chemistry. Beddoes was only at Oxford from 1788 until 1793, but for a time at least chemical interests there were stirred up by his enthusiasm; and it is on record that such was the revitalized interest he created that attendance at his lectures exceeded anything known in the University since the thirteenth century. Here in Oxford was the vivid effect of Black's infectious personality re-enacted. Beddoes' short readership in chemistry was but a phase in his life, and the Pneumatic Institute at Bristol which he founded spread Black's influence in another direction. It cannot be said that Beddoes' short sojourn at Oxford led to any great chemical efflorescence; but in 1803 a professorship of chemistry was endowed, and with it the establishment of regular teaching, something that had been in progress in Edinburgh for almost a century.

Cambridge was rather more fortunate than Oxford with its chemists. Richard Watson was followed by Isaac Pennington, and he in 1793 by W. Farish, who like Cullen in Glasgow lectured on the "Application of Chemistry to the Arts and Manufactures of Britain". In Farish's lectures we see a swing-over to an appreciation of the important contribution that chemistry was making to the industrial revolution. They covered smelting metallic ores, the uses of coal, such industrial chemicals as sulphur, alum, salt, acids, and alkalis, the chemical arts of bleaching and preparing cloth, and the production of mordants, etc. This highly practical approach heralded the further break with tradition, namely, the appointment of a chemist trained in the Scottish schools to the Cambridge chair. In 1813 Smithson Tennant (1761–1815), who had been in Cambridge since 1782, was appointed to the vacant chair of chemistry.

By this time Scottish chemistry, nurtured in the faculties of medicine at Edinburgh and Glasgow, had achieved a European reputation, and so the successors of Cullen and Black had an assured flow of talented students out of all proportion to that which came to Tennant and Beddoes, despite the latter's popularity as a lecturer.

When Black went to Edinburgh from Glasgow, he was succeeded by J. Robinson (1739–1805), and he in turn by William Irvine (1743–87), both students of his own. Irvine died in 1787, and was succeeded by Thomas Charles Hope (1766–1844). Hope only occupied the chemistry lectureship for four years before transferring to the chair of medicine, but his interest in research and his ability as a teacher maintained the reputation of the Glasgow school built up by Cullen and Black, whom he ultimately followed at Edinburgh as well (1799). Hope added still another of the elements (strontium) to be discovered by Scotsmen. On his translation to medicine he was succeeded by Dr. Robert Cleghorn (1777–1821), who continued to lecture on chemistry until an independent chair was founded in 1818.

This was an era of great industrial development by the application of chemistry to the arts in Scotland, during which the link-up between industrialists and universities was further strengthened. One need only mention in passing the introduction of chlorine bleaching at Gordon Barron and Company's Woodside Works through the activities of Prof. Patrick Copland (1749–1822), professor of natural philosophy in Marischal College, Aberdeen; the production of the dyestuff *cudbear* and the development of turkey red dyeing by George and Charles Macintosh, the latter a student of Black; the patenting of bleach liquor and bleaching powder in the name of Charles Tennant of St. Rollox, and the general contribution made by the Tennant-Macintosh nexus in the way of heavy chemicals and ancillaries to the dyeing and finishing trades. Under Hope's influence the development of chemistry was rapid and of increasing economic importance. On account of his professional contacts, Hope in some ways occupies a place of equal importance with Black, because increasing numbers of industrialists (for example, the Tennant and Macintosh group) were in a position to benefit by contact with chemistry in the universities of Scotland. The popularity of chemistry with all classes in Scotland became so great that Hope sometimes had five hundred students attending his lectures, and outside the University, interest was every bit as great. He continued to lecture until 1844, when he was succeeded by Dr. William Gregory as independent professor of chemistry, fully a quarter of a century later than the foundation of an independent chair in the more highly industrialized city of Glasgow.

LONDON'S WATER SUPPLY: SAFEGUARDING ITS PURITY IN PEACE AND WAR*

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History

NO story of London's water supply would be complete without some brief account of the historical background from which have emerged the methods of purification which now form our vital defences against the transmission of the germs of water-borne disease.

Prior to the fourteenth century, the citizens of London obtained their water from the River Thames and its tributary streams, or from springs and wells, which were plentiful. At that time the supply of water was a duty of the City Corporation, and it remained so until 1582, when a Dutchman named Peter Morrys was granted a 500-year lease at the nominal charge of 10*s.* per annum, with the right to supply water drawn from the River Thames by pumps driven by water-wheels set in one of the arches of the old London Bridge. This undertaking remained in the hands of the Morrys family until 1701, when it was transformed into a company, which also acquired the city conduits. Thus was the duty of supplying water to London relinquished by the constitutional authority and handed over to private enterprise.

The next incident of note was the construction of the New River, opened in 1613, to convey pure water from springs in Hertfordshire to the City. The success of the New River Company led to the granting of power by Parliament to other companies for the purpose of supplying water, and between the years 1669 and 1806 no fewer than seven such companies were promoted. At the time of their formation, those of the companies which drew water from the River Thames had their intakes in the tidal pool, which became increasingly polluted by the ordure of the City. This led to the succession of serious epidemics of cholera in London during the nineteenth century.

Meanwhile, however, two important measures had been taken: first, the introduction in 1826 of filtration through sand, and second, the passing of the Metropolis Water Act of 1852, which prohibited the abstraction of water from the River Thames below Teddington Weir and imposed, as a legal obligation, the filtration of all river-derived water and the covering of service reservoirs. The Metropolis Water Act of 1871 further contributed to the cause of purity by the appointment of an impartial water examiner who transmitted the reports of the analyst, at that time Prof. Frankland, to the Local Government Board, and who had other duties mainly inspectorial in nature. The water supply, however, continued to be the subject of public agitation, which culminated in the passing of the Metropolis Water Act of 1902, by which the Metropolitan Water Board was created to take over from the companies the duty of supplying water to London.

The Act of 1902 also placed upon the Board certain duties in connexion with laboratory examination designed to ensure the safety of the supply. This was the genesis of the present Water Examination Department, which came into being in November, 1905, with the appointment of Dr. (afterwards Sir) Alexander Houston as the first director. There were, thus, two persons whose duty it was to safeguard the purity of the supply: first, the water examiner, who was an officer of the Local Government Board; and second, the director of water examination, who was an officer of the Metropolitan Water Board. This state of affairs continued until the appointment of water examiner was abolished in 1921, and the duty of safeguarding the purity of the supply thus devolved entirely upon the director of water examination. In 1904 the Metropolitan Water Board finally took over the private companies, and the duty of supplying water to London was taken out of the hands of private enterprise and restored once more to the control of the representatives of the people, by whom it had been voluntarily surrendered more than two centuries before.

Methods of Purification

Until 1909, filtration through slow sand filters was relied upon for the purification of the river-derived water. Sir Alexander Houston, however, was responsible for the introduction of a number of revolutionary changes, chief among which were the regular use of water which had been purified by passage through a storage reservoir (1909), chlorination (1916), the use of primary mechanical filters antecedent to slow sand filtration (1923), and the use of ammonia as a means of reducing the tastes produced by chlorine alone.

The Metropolitan Water Board now comprises twelve filtration works and some sixty well stations. It supplies an area 575 square miles in extent containing more than 7,000,000 people. The water is supplied through a distribution system of pipes 8,000 miles in length. Approximately two-thirds of the water is derived from the River Thames, one-sixth from the River Lee, and one-sixth from deep wells sunk in the chalk.

The wells are usually of great depth and the water delivered from them is of excellent physical quality. For many years it was supplied without any treatment, but the increasing urbanization of the country districts around London and the excessive pumping which now takes place has led to a progressive deterioration in the quality of the water lying in the great chalk basin beneath London, and this has necessitated the chlorination of all well-derived water, but no other treatment is required.

The river waters, on the other hand, are heavily polluted and require somewhat elaborate purification.

* Substance of a discourse delivered at the Royal Institution on December 8.