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ON THE

ADVANTAGES TO BE DERIVED

FROM

The Adoption

OF THE

"LOCAL GOVERNMENT ACT,"

AS EXEMPLIFIED

IN CROYDON.

BY

EDWARD WESTALL, M.D.

HOMINI NIHIL UTILIUS SANITATE.

London:

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1865.

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PREFACE.

THE following is the substance of a paper read at the Crystal Palace, on the 22nd June, 1865.

At the request of many friends of sanitary improvement in Croydon, and more in distant parts of Kent, Sussex, and Surrey, I have been induced to republish the paper in detail, a large portion having already appeared in the Journal of the British Medical Association. It would have been much more full had I given but a tithe of the material at my command, but I have endeavoured to make my remarks as general, and to curtail its length, as far as possible, being especially careful to avoid all personalities: the motive—the public weal—must be my only excuse.

Several references having been made to the Bourne Water as one of the peculiarities of the Croydon district, I have appended a short paper on that subject by C. W. JOHNSON, Esq., F.R.S., and one on the geology of Croydon, by J. W. FLOWER, Esq.; and I believe they will be found interesting as bearing upon sanitary progress in Croydon.

Since writing the above, I find that the Medical Department of the Privy Council has commenced an enquiry into the working of the Local Government Act, in order to ascertain the results of its application to towns generally, and doubtless a Report will be published hereafter.

PAPERS AND REPORTS REFERRED TO.

Vital Statistics of England and Wales, compiled from Returns of the Registrar-General. 1841.

Lectures by Dr. Barnett and Mr. Bigg.

Government Inspector's Inquiry in reference to New Gas Company. 1848.

Publications of "Health of Towns Association." 1847.

Surrey Standard Files. 1848 and 1849.

Government Inspector's Report to the General Board of Health (Mr. Ranger's) Preliminary Inquiry. 1849.

Reports by R. D. Grainger and Henry Austen, Esqs., to the General Board of Health. 1853.

Report to the Local Board of Health, Croydon, by John Simon, Esq. 1853.

Statement of Preliminary Inquiry by Dr. Southwood Smith and Dr. John Sutherland on the Epidemic at Croydon. 1853.

Report of Inquiry by Dr. Neil Arnot and Mr. Page, C.E. 1853.

History of Sanitary Progress in Croydon, by Dr. Carpenter. 1859.

Report on the Water Case, by C. W. Johnson, Esq. 1859.

ADDRESS

TO THE

MEMBERS OF THE SOUTH-EASTERN BRANCH

OF THE

BRITISH MEDICAL ASSOCIATION,

READ AT THE CRYSTAL PALACE,

June 22nd, 1865.

GENTLEMEN,—I believe it to be generally understood, on occasions of our meeting in this beautiful building, that, beyond the ordinary business of the Branch, the little time at our disposal should not be taken up by any long discussion or address; but that it should rather be devoted to the pleasure, amusement, and instruction, afforded by the numberless works of art, and beauties of nature, brought together, I might almost say lavishly, within the Palace and its grounds. Nevertheless, as this especial meeting is held here in lieu of Croydon, I must not forget that the position I occupy to-day has more reference to my former residence in Croydon, than to any ability I possess for such a post of honour. I feel bound to bear in mind (in any matter I may bring forward) my former connection with that town, and endeavour to do credit to my old friends now residing there, and to tender my thanks to them, and the other members of the South-Eastern Branch of the British Medical Association, for their kindness; at the same time,

expressing a hope that they will not be very severely critical of the fulfilment of the office of their President.

Having relinquished the active practice of the profession for some years, I have been anxious to find a subject which, although not strictly professional, shall be interesting to this Branch of our Association; and with this view I have taken up the point of sanitary improvement in our towns, as collateral to, or in aid of, the present prevailing ideas on preventive medicine. I say towns, because it is there we meet with the greatest opposition to sanitary measures from the outset; not always perhaps openly, for there is a strength even in this fashion; and with all its higher interests, it is fortunately a fashion that only the most ignorant and selfish can resist. The Board of Health, with its Public Health Act of 1847, was not, nor is the Local Government Act, a popular measure; for, although it goes far towards protecting the best interests of the poor man, and thus trenches upon the too often avaricious, or parsimonious conduct of the cottage proprietor, at the same time it so far interferes with the liberty of the subject, as to deprive the poor man of one of his most cherished aspirations—the pig-stye at his back-door, which, with the consequent miasm, has too long been the bane of many close cottage districts.

As an example, both for evil incurred by long neglect, and for the good obtained by taking a bold course—so soon as opportunity offered—I shall take Croydon as my text, and, as candidly as possible, show the state of the town prior to any care being taken for the health of its inhabitants—during the operation of the projected improvements, and subsequently to the completion of the works. I hope to be able to make a sufficiently good case to justify me in bringing before you this otherwise almost threadbare subject, of which the Croydon people have already had *usque ad nauseam*.

Croydon, then, may be taken as a fair illustration, being

one of the towns included in the first order in Council (1849), under the General Board of Health, and having been the pioneer through all the difficulties of sewage, outfall, and water-rights, and the butt for actions-at-law, from any, and every one, who had, or fancied he had, a grievance; and because in many places where it is now proposed to adopt the Local Government Act, Croydon is held up as a bugbear, and as a total failure of all that was sought for; and, of course, with extravagantly increased parochial rates. In more than one town such *ex parte* reasoning (if it can be so called) has been successful, and the inhabitants are doomed by their authorities to go on amidst filth, and short or bad water-supply, in some places both, until, as in Croydon, the "darkness shall be felt."

I know that it has been said, that statistics can be made to prove anything. When truthful, they are, however, too useful to be dispensed with; and I shall append a few, which I trust will be interesting; but as this address must necessarily be short, I shall merely embody the result, as far as may be required to illustrate my case.

In the year 1831 I came to Croydon, at the recommendation of my friends, to commence practice; and, curiously enough, the chief inducement held out was its extreme healthiness. As is usual with young members of our profession, I was not overworked by patients within the first two years, and I had time to dispel the charming illusion ere long. Coming, as I did, from a large and well-regulated manufacturing town in Lancashire, a painful contrast was exhibited. No drainage, even from the surface; little water, and that for the most part bad in quality; paving only in the High Street; gas (16*s*. per 1,000 feet) in the hands of a private individual (the works and a fellmonger's yard in the heart of the town); and highways anything but good.

I do not deem it necessary to give any history of Croydon, or its peculiarities, here. In addition to several

standard works, ancient and modern, which refer to it, short papers have been written within a few years by Mr. C. W. Johnson, Mr. J. W. Flower, and Dr. Carpenter. Some extracts from these will be given in an appendix.

Prior to 1848, the town was supposed to be cared for by a Board of Commissioners, under a local Act (10th George IV., cap. 73, 1829); but for several years little else seems to have been done by this Board than to provide the judges of assize with lodgings (once in two years) and to light the town district. It was not an uncommon circumstance for a majority of this Board to refuse a vote of twopence or threepence in the pound, brought forward repeatedly by a small minority, for the purpose of commencing some system of drainage; and it was a matter of congratulation, when the Board broke up at the termination of their year of office, that no such money had been spent; but not without a warning of the result of their imbecility. Up to this time, no sewer nor close drain existed in Croydon. All the refuse of the closets and privies was drained by porous earthen pipes into cesspools, and eventually found its way by open ditches into two large ponds—heads of the River Wandle; and I well remember seeing some fine trout endeavouring to hold their own, when well nigh surrounded by the town sewage, at the back and within a few yards of the houses in the High Street. These cesspools were in the yards of the houses; or, in some cases, there was one large cesspool to a number of houses, and generally so close to the well (where one existed) that, on the occurrence of a heavy rainfall, the water became more or less tainted.

In the lower parts of the town especially, where the wells were only from three to six feet deep, it was an impossibility to keep the water pure; and at the periodical flowings of the Bourne water, the earth became fully saturated.

Is it surprising, then, that, with all these exciting causes,

there should be frequent prevalence of fever and other zymotic diseases? and that some of the more thoughtful inhabitants should begin to make inquiries?

The first movement was made by a few private individuals in the year 1846, in opposition to a gas company, who proposed to perpetuate the nuisance of works in the town. About this time, also, a report was obtained as to the water supply; and it was found, as I fear it would be in many places now, that one-half the houses had no wells or other source of supply. In many of those which had, the quality was bad.

The threatened attack of cholera soon after this (1848-49) began to call the attention of the authorities to the state of the town; and the country is deeply indebted to the Health of Towns Association, for keeping up a proper excitement on the subject; but until the passing of the Nuisance Removal Act (1846), there was no controlling power to remedy existing evils. In too many instances, these were not only tolerated, but fondly cherished; and the slightest interference was met by the old story of vested rights, or the cry of imperilling the liberty of the subject, with other like prejudices. So much was accomplished as could be, with the limited powers, and the cholera came pretty severely in 1849. In the meantime, steps were taken to apply the Public Health Act to the town, under the General Board of Health; and, after a public inquiry, the Inspector, Mr. Ranger, made his report in April, 1849, the Order in Council was obtained July, 1849, and the first election of a Local Board occurred in August, 1849. The works commenced in the autumn of 1850; and by the end of 1853, they may be said to have approached completion.

The works comprised an entirely new water-supply, from a deep well; the water being pumped up into a large covered reservoir, holding 900,000 gallons, at some distance, and at a height of 142 feet, to ensure constant

service, and to reach the highest houses; and a thorough system of sewerage by glazed earthenware pipes, both for sewers and house-service, by back drainage.

The completion of each of these undertakings involved the Board in great difficulties. In the first place, our right to raise the water, or at any rate, such a quantity as would sensibly decrease the underground flow to the River Wandle, was disputed; for it was never intended to interfere with the stream; but merely to supply the mass of houses from one well, by suitable machinery, instead of each house having its own well. The well used by the Board was one which had been more or less public ever since the town had existed. An association of millers from all parts of the kingdom determined to dispute, or question, our power (by law) to effect the object desired. After two years of litigation, and at a cost of £5,000 to the parish, and much more to the millers, it was finally decided in the House of Lords on July 29th, 1859:—1. "That the underground water in the land belongs to the owner of the ground;" and 2. "That he may drain that water out of his land, in any direction that he finds the best, for his, or its enjoyment or cultivation."

As to the water-supply for towns, I believe that had the sanitary movement in Croydon done no more than establish, as it has done, the absolute right to underground water, it would have achieved a benefit for the community at large—not too dearly bought—costly as it was to all parties concerned. The water-supply of Croydon leaves nothing to be desired on that head. There is a constant supply of the purest quality; and if anything be lost in its comparative hardness, it is fully compensated for by its freshness. I may safely say that it cannot be excelled. The supply was calculated at eleven gallons per head daily; it now ranges from forty-six to fifty-six gallons. The charge for this wonderful accommodation is exceedingly small—to the cottager one penny per week, and to the larger house-

holders about one-fourth the rate of the water companies. It is proposed to extend the benefits of the water supply to a larger district, and the additional expenses will be met by an increased charge in the new district, as this district does not contribute out of any rate towards the liquidation of the capital expended in the construction of the water-works. The surplus income, which is considerably increasing, yields a large sum towards the reduction of the rates.

Our difficulties with the sewerage and drainage were even more serious, involving, as they did for a time, an increased mortality from zymotic diseases; and Croydon became the battle-field of the pipe-gauges, and controversialists on the value of solid and liquid manure. In addition to our local obstacles, which were not a few, we met opposition and objection from every quarter.

Before one step could be taken, a mill, which had been erected less than forty years, within three hundred yards of the church, whereby the water-line of the town was raised seven feet and a half, had to be purchased and removed, and a large culvert formed, to conduct the Bourne and storm waters through the lower parts of the town. As no power existed at this time to take the sewage matter beyond the limits of the parish, good as the outfall may be, the intervening distance was too short to admit of any sufficient or effectual means of deodorisation. All attempts to send the strained water into the river, even in a state of comparative purity, were unavailing. Actions at law and repeated injunctions interfered with our progress; until an amended Act of Parliament gave us power to extend our works beyond the parish, and enabled us by irrigation to free ourselves and others from the nuisance, and to prove the question of the utilisation of sewage. Croydon had no alternative; the best possible temporary arrangement was made for filtration and deodorisation; but the opposition to passing the sewage beyond the parish was too strong until Parliamentary powers were obtained. Irrigation was intended from the first. At present,

the high rental of land, being so near London, prevents a large profit, although the irrigation is effected by gravitation; but where the land is of less value, or where the pumping of the sewage to a higher level can be done at a less cost than now, as doubtless it will be ere long, the sewage will become a source of large profit, and thus still further conduce to the reduction of the rates.

But, you will say, After all your trouble and expense, you had an increase of fever and other zymotic disease. That cannot be denied; but I question if the amount in the outbreak anything like equalled what must have proved the continued ratio, had matters remained as they were. I will give briefly the causes; for it is matter of history now, and can be looked upon dispassionately. Many mistakes were made, as usual in all transitions, even from a bad to a good system. First, too large a surface of ground was opened at one time, and allowed to remain open too long; that ground being a soil more or less saturated by impurities from cesspools, old dung-pits, etc.; and, by the adoption of back drainage, this evil was greatly aggravated. A large rainfall (34 inches, the average being about 24); a high mean temperature (50·17), and the flow of the Bourne (a periodical stream before alluded to), added to the mischief by filling the trenches, causing percolation into the wells, and the exhalation of much noxious vapour.

In addition to these causes, no provision having been made for ventilating the sewers, many of the closets and sinks in the upper part of the town became stink-traps, for the escape of the tainted air into the houses. There was quite enough to bring fruit from the seed sown by neglect of all and every precaution for so many years before.

It must be borne in mind, also, that fever was prevalent in many of the towns of nearly every county in England, in that year, 1852. We must not suppose that such mischief can occur again, or in other places, however bad they may be, with this experience before them, and only moderate precaution.

The population of Croydon increased from 5,743 in 1801, to 30,240 in 1861, and is now computed at about 40,000; that of the town proper about 18,000—the ratio per house being, in 1851, $6\frac{1}{3}$; in 1861, $5\frac{7}{8}$; and now about $5\frac{3}{4}$. The more favourable condition in the ratio per house arises chiefly from the large number of first-class cottages recently erected; also, from the care bestowed by the police in their regulations for Lodging-houses, and the stringent bye-laws of the Local Board. The increase of population is, despite of the removal of three large establishments — the London District Schools, the Addiscombe College, and the Barracks—in all embracing from 1,500 to 2,000 persons.

Having been a member of the Local Board of Health for nearly ten years from its first election, I may be supposed to have had some experience; and I will now, in a few words, offer such advice as that experience will warrant. First, medical men should take the initiative in all sanitary movements. We have proved in Croydon that much may be done in educating the poor and lower classes, to the value of cleanliness, health, and comfort. Next to the clergy—indeed, often before them—none have so good opportunities as members of our profession. I say it in all thankfulness, that in Croydon, with rare exceptions, they were foremost in action; and, in addition to other means, many hundred pamphlets were distributed amongst the cottagers, and read by them, chiefly published by the Health of Towns Association. Next, I would say, Be not content with half measures. To meddle, bit by bit, is to ensure mischief. I could readily illustrate this by reference; but it is needless. Obtain full powers at once, and, with the examples of other towns before you, the best systems will be adopted. There need be no battle of pipe-gauges; no question of water-supply, excepting as to the best sources. Care should be taken to remove all existing nuisances, such as gas-works, slaughter-houses, and public

works of all kinds, from the town. All open ponds into which refuse of any kind can be thrown, should be cleansed and filled up; a thorough system of scavenging should be adopted, with a house-to-house collection of dust and other refuse. All footpaths, alleys, and courtyards, should be paved or asphalted. On this latter point, I fear much of the good obtained by the wider roads, and the larger area allowed to cottage property, is lost, by admitting accumulations of manure, decaying vegetable matter, etc., in the yards and gardens. There is one point upon which I feel that particular stress should be laid; although, perhaps, it belongs rather to the engineer—that is, the avoidance (if possible) of back drainage. It is a constant source of annoyance and discomfort, if not of disease. When a stoppage occurs, it is not easily found out, without disturbing many yards and gardens (in some instances from ten to twenty)—the soil from which has to be exposed for some time. The house-drains cannot well be too small, nor the sewers too large: the latter, to allow of frequent inspection; the former, to prevent the introduction of foreign matters, and to admit of thorough flushing. As a measure of economy in the water-service, every house should be furnished with a cistern for the closets and cleansing purposes, in addition to its taps for drinking and cooking.

I am not one of those who believe all zymotic diseases to be preventable; so long as poverty, ignorance, and vice prevail, so there will be their concomitants of disease. We may do much, and ought to act with hope, to obtain the highest possible results for our (poor at the best) endeavours; but in this life we may not even dream of perfection.

The late Mr. Grainger, so lately lost to us, and whose memory deserves a hearty tribute from our profession, in a Report made to the General Board of Health in 1853, says: "On referring to the statistics of Surrey, for 1841, it appears that, on comparing the several registration districts in the county, as to epidemic disease and mortality

generally, that of Croydon holds an unfavourable position at each stage of life." He also shows, the death-rate from Fever to have been, from

1840 to 1845 ..... 4·6 per cent.
1845 to 1850 ..... 7·6 „

And all Zymotic Diseases,

1840 to 1845 ..... 19·0 „
1845 to 1850 ..... 26·1 „

I find in the three years 1848-49-50, the following death-rate:

Fever.	All Zymotic Diseases.
7·95 per cent.	27 per cent.

Thus the danger was still increasing.

In the years 1851-52-53, when the works were in operation and the fever was epidemic, the mortality showed a very inconsiderable increase; being

Fever.	All Zymotic Diseases.
8·3 per cent	25.6 per cent.

After the completion of the works, the death-rate in 1854-55-56, was

Fever.	All Zymotic Diseases.
4·7 per cent.	22 per cent.

Taking the two periods of ten years, years 1845-54 and 1855-64, the death-rate was

Fever.	All Zymotic Diseases.
1845-54—7.5 per cent.	27·3 per cent.
1855-64—3.1 per cent.	17·2 per cent.

The deaths from cholera were, in 1849, 10.3 per cent., in 1854 7·8 on the gross mortality.

These figures speak for themselves. The details I will place before you; but they are too voluminous for this paper.

The birth-rate in the ten years:

1845 to 1854 ..... 2·912 per cent.
1855 to 1864 ..... 3·141 „

The proportion of deaths to the population was, in the years 1845-54, 1 in 48; 1855 to 1864, 1 in 54.

The average duration of life was, in the years 1845-54, 30 years 1 month; 1855-64, 33 years.

The deaths under 20 years of age were, in the years 1845-54, 51 per cent.; 1855-64, 41·4 per cent.

The infant mortality has varied but little; being, under one year, about 1 in 7.

The foregoing figures show clearly the advantages derived from the sanitary works at Croydon.

In addition to the present benefits, of a constant and full supply of pure water—forty-six gallons per head to about 27,000 inhabitants (the outer portions of the parish being supplied by the Lambeth works, or by wells)—every house is connected with the sewers by glazed earthen socket-pipes, the larger sewers being of brickwork in cement, discharging at five different outfalls, intended eventually to converge by one main drain, on to the irrigation farm at Beddington, of about 300 acres, one mile distant from Croydon; the farm yielding a profit rental to the town of £1 per acre. Every house, or series of houses, is ventilated by the rain-water stack-pipes, or by upright pipes placed outside the houses. All the drains and sewers are flushed at frequent intervals, and a thorough system of scavenging is carried out. The old slaughter-houses are carefully watched; and others have been erected by the Board, outside the town.

An excellent code of Bye-Laws has been framed by the Board, and sanctioned by the Secretary of State, in which are stringent regulations referring to cottage buildings; more especially applying to their ventilation, lighting, and the area of the rooms; the frequent objections made to these by builders fully illustrate their necessity, and it is to be hoped that the Board will not relax in the endeavours to enforce these most salutary aids to health, amongst the poorer classes of society.

The result is a large decrease of sickness, especially amongst the poorer classes; a very large increase of population; the birth-rate increased from 2·91 to 3·14 per cent.; and the deaths decreased from 2·366 to 1·845 in the thousand—showing a saving of above two hundred

lives per annum. Excepting in extreme infancy, the average deaths at all ages have materially decreased; and, even when the infant deaths are taken at the old rate, all those under twenty years of age have decreased by nearly 10 per cent. Taking the deaths from fever and all zymotic diseases alone, the decrease is respectively from 6·1 per cent. to 3·1 per cent., and from 22·5 per cent. to 17·2 per cent.—taking from the year 1845, and including the two unhealthy seasons of the years 1863-64.

These, then, are some of the results of the application of the Local Government Act (patent to all) to Croydon, a town in many respects not most advantageously situated, by reason of its proximity to London, of which, in fact, it is a suburb; and by its being the chief town of a large agricultural district, the majority of the lower classes, male and female, obtaining their livelihood by out-of-door work, and thus, perhaps, greatly accounting for the large infant mortality; also by the daily passing through of a large number of tramps; and, again, as containing the union-house for nine parishes and two hamlets (for which no deduction has been made in the calculations). That there are results far higher than these, of a religious and moral character, we may be assured; and the Croydon rate-payers may well be satisfied that they have not exercised a large amount of self-denial and perseverance in vain, but that they have added somewhat to the improvement of their fellow-men, and thus, humbly though it be, joined in the tribute of glory and praise to Him, who gave us so great an example of beneficence, and have endeavoured to fulfil their highest duty on earth.

APPENDIX.

EXTRACT FROM THE FIRST REPORT OF TOWN COMMISSIONERS' COMMITTEE ON THE SANITARY STATE OF CROYDON, *April 1st*, 1848.

Your Committee, having personally inspected all those parts of the town which, from their locality, and the class of inhabitants, were supposed to be most wanting in the necessaries to an effectual drainage, &c., are of opinion :—

Sewerage and Drainage.—That the Town of Croydon is, on the whole, utterly devoid of any system of sewerage, and that the drainage is altogether inefficient, being nearly confined to the surface.

Water Supply for Ordinary Purposes.—The water supply of Croydon, which, by proper management and a moderate outlay might be rendered good, both in quality and quantity, is inadequate to the wants of the inhabitants, especially the poorer classes.

State of Courts, Lanes, Bye-Ways, &c.—The streets, lanes, and courts, not immediately under the Board of Highways, are in a very deplorable condition, and unfit for ordinary traffic. Your Committee regret that the powers of the Boards of Commissioners of the Town and of Highways are altogether inadequate to the perfect cleaning and maintaining of many of the bye-ways of the town.

Contamination of Wells and Water Nuisances.—There are very few wells in the town free from contamination from the refuse of the houses, dunghills, or drains, in consequence of the superficial drainage; and your Committee were obliged to hear complaints from every class of the inhabitants of the injury sustained by that cause, more especially in the densely populated

districts of the upper and lower towns, and they had occular demonstration of the existence of such nuisances as dunghills placed in front, or within a few feet, of the windows of cottages, from want of room, or for the sake of profit.

PRIVY ACCOMMODATION.—The average of privies among the poorer classes is not above one to three houses, many of these houses containing several families; and in many places the excrement of children might be seen spread over the extent of the court or yard.

It may be asked, what your Committee recommend?—That some steps should be immediately taken to palliate, if not remove, the more pressing evils; or, in the event of the expected visit of the cholera, there will be much to answer for. A difficulty arises from the limited powers entrusted to the Board of Town Commissioners, but landlords of cottage property may do much.

AUTHORITIES.—The Board of Highways, the Town Commissioners, the police, and the medical profession, may each and all assist in the amelioration of such a state of things.

ACTS OF PARLIAMENT.—There are certain Acts of Parliament which may be made available by each of these bodies; and though a radical improvement cannot take place, still the way may be paved, and by commencing now the path will be more easy when (if ever) our powers are increased.

Your Committee think it better not to advise any specific course, but rather (having directed attention to the sanitary deficiencies) to leave each authority to act as it shall deem most advisable under the circumstances.

In the present posture of our social condition in Croydon we cannot hope for great moral, much less religious, progress among our poorer neighbours; but the day must, and, ere long, will come when obligation will drive us, if we now allow inclination to retard us, in promoting their welfare.

Let us assist them in their endeavours to improve their condition, who are already fully prepared to take advantage of, and to profit by, our good will.

(Signed) GEO. W. MATTHEW,
GEORGE PRICE,
ROBERT PLEDGE,
J. W. EDWARDS,
EDWARD WESTALL.

OPPOSITION OF RATEPAYERS, 1849.

EXTRACT FROM "SURREY STANDARD."

"It is needless, however, to pursue the subject, with such a mass of evidence before them as is presented to our readers in the inquiry which has just terminated at Croydon. The evils and the remedies—the 'bane and antidote'—are clearly and strikingly exhibited, and yet with such positive and undeniable evidence of the fearfully unhealthy condition of the town—though their unfortunate fellow-creatures are dying around them from causes which could easily be prevented—in the face of all this there are men to be found who are doing all they can to frustrate the benevolent design of conveying health (and consequently increased happiness) to the cottages of the poor. To the indelible disgrace of the ratepayers, a small knot of would-be economists, who, forsooth, arrogate to themselves the title of "*liberals*," have been permitted to eject from the Board of Town Commissioners several of its most useful members because they are in favour of sanitary improvements! There was, however, one redeeming circumstance in connection with this event. A gentleman, otherwise connected with them by party ties, indignantly gave up his office as commissioner in perfect disgust at such conduct. The noisy vociferousness of these individuals was so great, that six or seven of them were occasionally speaking at one time, and though rebuked in the most mild and gentlemanly terms by the worthy vicar and Mr. Blake, the confusion and uproar continued to the last. The purport of these remarks will at once be seen by those of our readers who were present at a recent vestry meeting.

"We should not be doing our duty, if we did not warn the poorer class of inhabitants against being led away by the false cry of 'economy' raised by these men. Economy, indeed! Those are the best friends of the poor, even in an economical point of view, who seek to remove the causes of disease and pestilence from their dwellings, to promote their comfort and to elevate their condition. The working men of Scotland, and in the northern and midland districts, saw the question of sanitary reform in its true and proper light, and, by an united and energetic declaration, that they were no longer content to drag on a miserable existence with the elements of disease in and around their habitations, at once silenced the 'economists' of their several districts. We have confidence that the working classes of Croydon will not be less sensible to the great value of sound sanitary regulations, and generally will hail with pleasure the dawn of the 'better days coming,' when their houses will be fit to dwell in, and their families have the advantage of those necessary requisites to health—good ventilation, good light, efficient drainage, and a constant supply of good water."

FEVER.

In 1847, Mr. Bottomley treated 300 cases of fever (chiefly Irish).

Fever prevalent at Blofield, Norfolk; East Budleigh, Devon; Chatteris, Cambridge; Bedford, Wilts; Amesbury, Wilts; Redruth, Cornwall; Wigan, Lancashire; Southsea, Hants; Portsea, Hants; Brighton, Sussex.

"The first case of fever seen at Croydon was imported from Oxted, a fact corroborated by Drs. Southwood Smith and Sutherland, and admitted by Mr. C. R. Thompson to be similar in type to a case he subsequently saw from Croydon. In Oxted, out of a population of 500, there occurred 80 cases of fever."—*Report by R. D. Grainger*, 1853.

INCREASE IN THE POPULATION OF CROYDON.

1801	5,743	1841	16,712
1811	7,801	1851	20,355
1821	9,254	1861	30,240
1831	12,447	1865	40,000 about.

1831.—Value of land in and near the town, £100 per acre.

1861.—Ditto, ditto, £1,000 per acre, still increasing.

A heavy penalty is involved in the large and rapid increase of population, the Registrar-General's tables showing that, according to the density, so may the ratio of mortality be reckoned. Thus, Croydon and other districts, having a population under 200 to the mile, have a mortality below 20 in the 1000; and as the density increases, so does the comparative mortality, up to 33 in the 1000.

Cost of the works in the General District, £27,350. Ditto, Special District, £48,162. The money is borrowed on loans for thirty years; the present rate being 1s. to 1s. 4d. in the pound for repayment of loan.

The Poor Rate is considerably reduced.

GAS.

The promise given by the Gas Company in the year 1846 is only now about to be redeemed, notice having been given for the removal of the works from the town, 1865.

WATER, 1849.

A house-to-house inquiry proved that to 1,550 houses there were only 634 wells; 755 houses had no supply whatever; and in 276, where wells existed, the water was bad or deficient. Some of the poor were compelled to purchase beer at the public-houses to obtain any water.

Croydon Water Rate. Scale of Charges, 1865.

Assessment not exceeding £ s. d.	In Special District. £ s. d.	Out of Special District. £ s. d.
5 10 0	0 4 4	0 6 6
8 10 0	0 5 0	0 8 8
10 0 0	0 6 0	0 12 0
12 0 0	0 7 0	0 14 0
15 0 0	0 8 0	0 17 0
20 0 0	0 9 0	1 1 0
25 0 0	0 10 0	1 5 0
30 0 0	0 11 0	1 9 0
35 0 0	0 12 0	1 13 0
40 0 0	0 13 0	1 17 0
45 0 0	0 14 0	2 1 0
50 0 0	0 15 0	2 5 0
55 0 0	0 16 0	2 9 6
60 0 0	0 17 0	2 13 0
70 0 0	0 19 0	3 1 0
80 0 0	1 1 0	3 9 0
90 0 0	1 3 0	3 17 0
100 0 0	1 5 0	4 5 0
120 0 0	1 9 0	5 1 0
140 0 0	1 13 0	5 17 0
160 0 0	1 17 0	6 13 0
180 0 0	2 1 0	7 9 0
200 0 0	2 5 0	8 5 0

Analysis of Water, Croydon, by Professor Way. Samples from the Well.

	March, 1852. Gr.	Jan., 1853. Gr.
Organic Matter and Combined Water	1·09	0·98
Silica	·93	·84
Sulphate of Lime	·53	·74
Carbonate of Lime	15·41	14·64
Chloride of Sodium	1·51	1·34
Carbonate of Magnesia	·61	·76
Sulphate of Soda	·18	·20
Sulphate of Potash	·85	·74
Grains of Residue in a Gallon	21·11	20·24
Hardness in Clarke's degrees—		
Before Boiling	16°	15½°
After Do.	4½°	4°

Annual Per Centage of Fever, and all Zymotic Diseases, to Gross Mortality, 1848 *to* 1864.

Year.	Fever.	All Zymotic Diseases.	Prevailing Epidemics.
1848	7·6	36·6	
1849	8·5	37·2	First Cholera year.
1850	7·5	26·9	First Sanitary movements.
1851	2·6	14·7	
1852	7·8	27·3	
1853	12·4	31·4	Fever year.
1854	6·2	32·2	Second Cholera year.
1855	5·9	16·7	
1856	3·0	18·5	Small-pox.
1857	3·2	14·8	
1858	4·1	17·3	
1859	1·8	20·7	Scarlatina—Whooping-cough.
1860	1·3	9·2	
1861	1·9	9·6	
1862	4·5	18·9	Scarlatina—Whooping-cough.
1863	2·6	26·2	Scarlatina—Small-pox.
1864	3·4	18·3	Scarlatina—Small-pox—Whooping-cough.
1848 to 1854	7·5	28·5	7 years' average.
1848 to 1864	4·9	21·8	17 years' average.
1855 to 1864	3·1	17·2	10 years' average.

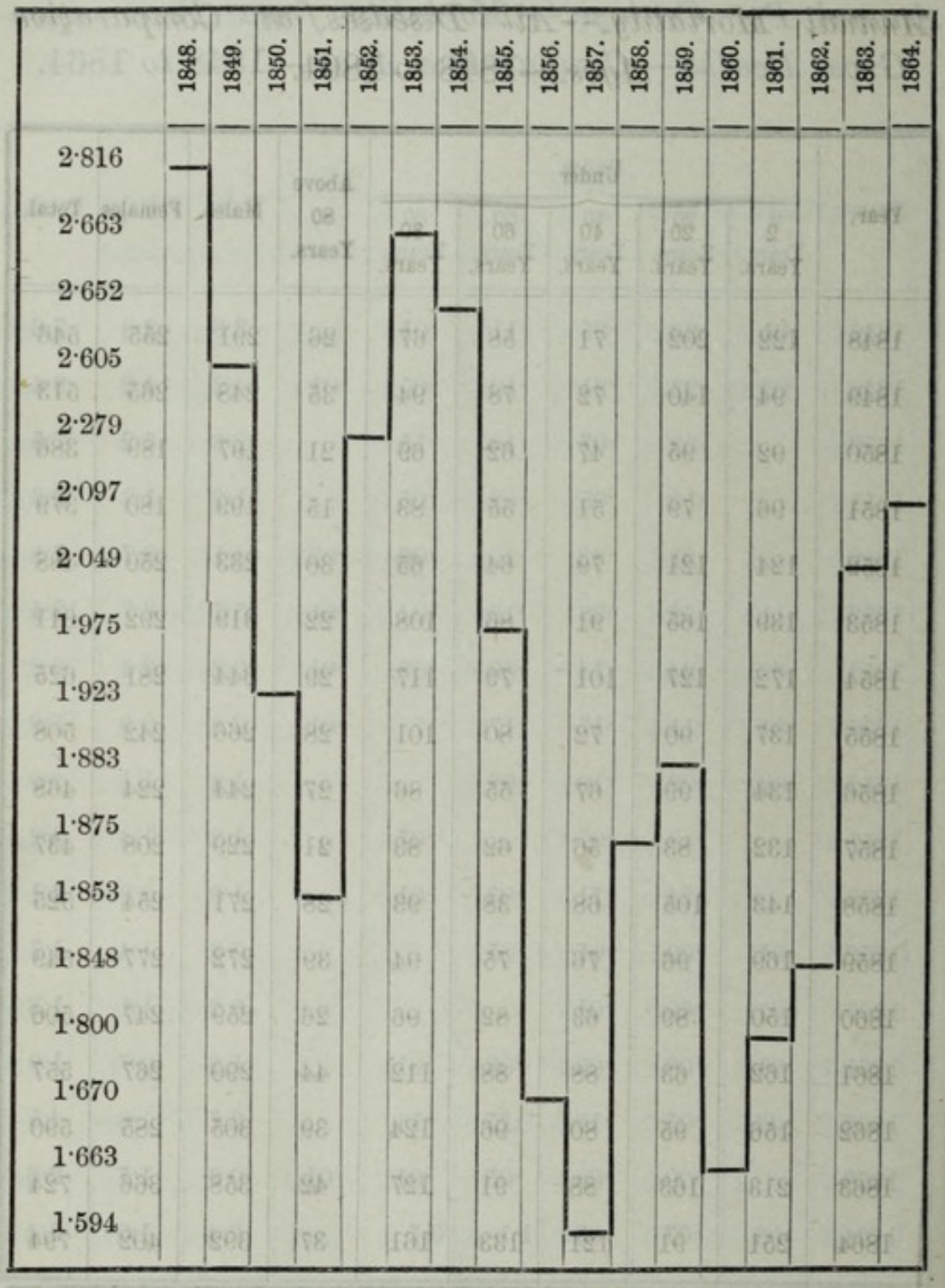
Annual Mortality.—Fever at Comparative Ages.—1848 *to* 1864.

Year.	Under					Above	Males.	Females	Total.
	2 Years.	20 Years.	40 Years.	60 Years.	80 Years.	80 Years.			
1848	1	20	14	6	1	0	21	21	42
1849	2	17	11	10	3	1	22	22	44
1850	0	15	3	5	6	0	9	20	29
1851	0	5	2	1	2	0	5	5	10
1852	0	15	11	8	3	1	20	18	38
1853	7	32	22	11	3	1	35	41	76
1854	2	15	9	6	6	1	24	15	39
1855	1	6	9	9	4	1	15	15	30
1856	1	4	5	4	0	0	9	5	14
1857	0	8	3	0	3	0	8	6	14
1858	0	13	6	2	1	0	7	15	22
1859	1	5	1	3	0	0	2	8	10
1860	1	5	1	0	0	0	1	6	7
1861	1	5	2	2	1	0	7	4	11
1862	2	3	6	9	7	0	16	11	27
1863	0	7	6	4	1	1	7	12	19
1864	3	6	3	9	6	0	19	8	27

Annual Per Centage.—Mortality from Fever upon Gross Deaths.—Comparative Ages.—1848 *to* 1864.

Year.	Under 2 Years.	Under 20 Years.	Under 40 Years.	Under 60 Years.	Under 80 Years.	Above 80 Years.	Males.	Females	Total.
1848	·01	·36	·25	·11	·01	...	3·8	3·8	7·6
1849	·03	·33	·21	·19	·05	·01	4·2	4·2	8·4
1850	...	·39	·07	·13	·15	...	2·3	5·2	7·5
1851	...	·13	·05	·02	·05	...	1·3	1·3	2·6
1852	...	·31	·22	·16	·06	·02	4·1	3·7	7·8
1853	·11	·52	·36	·18	·04	·01	5·7	6·7	12·4
1854	·03	·24	·14	·09	·09	·01	3·8	2·4	6·2
1855	·01	·11	·17	·17	·7	·01	2·9	2·9	5·8
1856	·02	·08	·10	·08	...	...	1·9	1·1	3·0
1857	...	·18	·07	...	·07	...	1·8	1·4	3·2
1858	...	·24	·11	·03	·01	...	1·3	2·8	4·1
1859	·01	·09	·01	·05	...	...	0 3	1·4	1·7
1860	·01	·09	·01	...	...	...	0 2	1·1	1·3
1861	·01	·08	·03	·03	·01	...	1 2	0·7	1·9
1862	·03	·05	·10	·15	·11	...	2·7	1·8	4·5
1863	...	·09	·08	·05	·01	·01	0 9	1·7	2·6
1864	·03	·07	·03	1·1	0·7	...	2·4	1·0	3·4

Annual Per Centage of Deaths from all Diseases, with Fluctuations, 1848 *to* 1864, *to Population.*



Average, 7 years, 1848 to 1854 . . . . . 2·366.
„ 17 „ 1848 to 1864 . . . . . 2·073.
„ 10 „ 1855 to 1864 . . . . . 1·845.

Annual Mortality.--All Diseases at Comparative Ages.—1848 *to* 1864.

Year.	Under					Above 80 Years.	Males.	Females	Total.
	2 Years.	20 Years.	40 Years.	60 Years.	80 Years.				
1848	122	202	71	58	67	26	291	255	546
1849	94	140	72	78	94	35	248	265	513
1850	92	95	47	62	69	21	197	189	386
1851	96	79	51	55	83	15	199	180	379
1852	124	121	79	64	65	30	233	250	488
1853	139	165	91	86	108	22	319	292	611
1854	172	127	101	79	117	29	344	281	625
1855	137	90	72	80	101	28	266	242	508
1856	134	99	67	55	86	27	244	224	468
1857	132	83	56	62	83	21	229	208	437
1858	143	105	68	38	93	28	271	254	525
1859	169	96	76	75	94	39	272	277	549
1860	150	89	63	82	96	26	259	247	506
1861	162	63	88	88	112	44	290	267	557
1862	156	95	80	96	124	39	305	285	590
1863	213	163	88	91	127	42	358	366	724
1864	251	91	121	133	161	37	392	402	794

Annual Per Centage.—All Diseases at Comparative Ages.—Mortality to Gross Deaths.—1848 *to* 1864.

Year.	Under 2 Years.	Under 20 Years.	Under 40 Years.	Under 60 Years.	Under 80 Years.	Above 80 Years.	Males.	Females.
1848	22·3	37·	13·	10·6	12·2	0·47	53·1	46·7
1849	18·3	27·2	14·	15·2	18·3	0·52	48·3	51·6
1850	23·8	24·6	12·1	16·	17·8	0·54	51·	48·7
1851	25·3	20·8	13·4	14·5	21·9	0·39	52·5	47·4
1852	25·6	25·	16·3	13·2	13·4	0·62	48·2	51·5
1853	22·7	27·	14·9	14·	17·6	0·36	52·2	47·7
1854	27·5	20·3	16·1	12·8	18·7	0·46	55·	44·9
1855	26·9	17·7	14·1	15·7	19·8	0·55	52·3	47·6
1856	28·6	21·1	14·3	11·7	18·3	0·57	52·1	47·6
1857	30·2	18·9	12·5	14·1	18·9	0·48	52·1	48·3
1858	27·2	20·	12·9	16·7	17·7	0·53	51·6	48·8
1859	30·7	17·4	13·8	13·6	17·1	0·71	49·5	50·4
1860	29·6	17·5	12·4	16·2	18·8	0·51	51·1	48·8
1861	29·	11·3	15·8	15·8	20·1	0·78	52·	46·1
1862	26·4	16·1	13·5	16·2	21·	0·66	51·6	48·3
1863	29·4	22·5	12·1	12·4	17·5	0·58	49·4	50·5
1864	31·6	11·4	16·8	16·8	20·2	0·46	49·4	50·6

Annual Per Centage.—All Diseases at Comparative Ages.—Mortality to Population.—1848 *to* 1864.

Year.	Under					Above	Males.	Females	Total.
	2 Years.	20 Years.	40 Years.	60 Years.	80 Years.	80 Years.			
1848	·629	1·04	·366	·299	·340	·134	1·50	1·31	2·81
1849	·477	·711	·365	·391	·477	·177	1·26	1·34	2·60
1850	·458	·474	·234	·308	·343	·104	·980	·941	1·92
1851	·471	·388	·250	·270	·407	·073	·977	·884	1·86
1852	·584	·570	·372	·301	·306	·141	1·09	1·17	2·26
1853	·605	·721	·396	·375	·471	·095	1·39	1·27	2·66
1854	·729	·538	·428	·335	·496	·123	1·45	1·19	2·64
1855	·530	·348	·278	·309	·390	·108	1·03	·93	1·96
1856	·478	·353	·239	·196	·307	·096	·87	·80	1·67
1857	·481	·302	·204	·226	·302	·076	·84	·75	1·59
1858	·507	·372	·241	·312	·330	·099	·96	·90	1·86
1859	·579	·329	·260	·257	·322	·133	·93	·95	1·88
1860	·484	·287	·203	·264	·309	·083	·84	·79	1·63
1861	·523	·203	·284	·284	·361	·142	·94	·86	1·80
1862	·488	·297	·250	·300	·388	·122	·95	·89	1·84
1863	·602	·461	·249	·257	·359	·118	1·01	1·03	2·04
1864	·678	·240	·319	·351	·425	·097	1·03	1·06	2.09

Annual Births.—Population and Birth Rate.—1848 *to* 1864.

Year.	Male.	Female.	Total.	Male.	Female.	Total.	
1848	260	262	522	1·34	1·35	2·69	
1849	297	290	587	1·50	1·48	2·98	
1850	267	298	565	1·32	1·48	2·80	
1851	312	291	603	1·53	1·44	2·97	
1852	331	287	618	1·56	1·31	2·87	
1853	347	368	715	1·51	1·60	3·11	
1854	374	333	707	1·59	1·41	3·0	
1855	383	364	747	1·48	1·41	2·89	
1856	391	356	747	1·39	1·27	2·66	
1857	368	407	775	1·34	1·48	2·82	
1858	446	447	893	1·58	1·59	3·17	
1859	492	442	934	1·69	1·51	3·20	
1860	498	478	976	1·60	1·55	3·15	
1861	531	479	1010	1·75	1·58	3·33	
1862	536	545	1081	1·68	1·70	3·38	
1863	633	563	1196	1·79	1·59	3·38	
1864	664	637	1301	1·75	1·68	3·43	
1848 to 1854	312	304	616	1·47	1·44	2·91	Average 7 years.
1848 to 1864	419	403	822	1·55	1·49	3·04	Average 17 years.
1855 to 1864	494	472	966	1·60	1·54	3·14	Average 10 years.

Average Birth Rate, all England, 3·273.

Annual Average.—Temperature and Rainfall.—1848 *to* 1864.

Year.	Mean Temperature.	Rainfall in Inches.
1848.....	49·91	31·21
1849.....	48·38	22·92
1850.....	47·92	17·81
1851.....	49·84	21·01
1852.....	50·17	33·92
1853.....	48·49	30·51
1854.....	51·3	16·02
1855.....	48·24	23·26
1856.....	48·12	23·95
1857.....	51·99	24·88
1858.....	49·52	18·09
1859.....	51·07	31·82
1860.....	47·29	33·82
1861.....	49·75	21·
1862.....	49·36	29·42
1863.....	50·52	25·01
1864.....	49·39	18·02

NOTES ON THE GEOLOGY OF CROYDON.

BY J. W. FLOWER, ESQ.

Croydon is situate on the margin, or circumference, of the great basin of London clay, on which the metropolis (from which this formation takes its name) is built. The town is placed on a platform or delta, of ferruginous gravel, at the mouth of a valley, or rather near the confluence of two valleys or passes, and at the foot of the range of chalk hills known as the North Downs. One of these valleys extends as far as Godstone, and the other (more to the west) nearly to Merstham. It is probably from these valleys, or at least from that leading from Godstone, that Croydon takes its name. In the oldest record extant in which it is mentioned (circa 962) it is termed Crogdene—the crooked or winding valley.

In some places, the gravel is found to rest directly upon the chalk, as at Duppas Hill and the Waldrons. More to the north, it rests upon the London clay; while near the bridge in Coombe Lane, and in some few places south-west of the town, it lies on the Thanet sands of the plastic clay which overlie the chalk, and underlie the London clay. It is never found upon the summit of the hills, but rises to a certain height upon the western slope, apparently indicating the height of the current of drift, which once swept through the valley, and the presence of which deposit probably indicates the last great geologica change to which the district was subjected.

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It is evident, that before the gravel or drift was deposited in its present position vast changes had occurred

in the subjacent beds. The chalk, which is found at the *surface*, near the bridge in Coombe Lane, is seen to dip rapidly towards the north, at an inclination of about one in six; at Ashby's steam-mills, about half a mile distant, it is found to underlie the London clay and plastic clay beds, at a depth of 120 feet; while in London, which is ten miles distant, it is only reached at the depth of from 300 to 400 feet. The depression thus formed is filled up by the beds of the plastic clay and London clay series: but the London clay is found very sparingly, if at all, south of the Brighton Railway station. In that direction, the plastic clay beds, which in order of superposition, should underlie the London clay, are seen rising on the east to the height of fifty or sixty feet; while to the south and south-west we find the bare Chalk Downs.

But, as all these beds must have been originally horizontal, it follows, that after the London clay was deposited, some enormous depression must have taken place in the centre of what is now the London clay basin, or some elevation of the margin or circumference; and that thus the body of the London clay south of the Brighton railway station, and at some places (as at Purley and Haling, and in Coombe Lane) the subjacent beds of plastic clay also, must have been carried away; and occasionally, as in Coombe Lane and at Ballards, channels were cut in the chalk itself.

Abundant evidence of the ruin and degradation of the plastic clay beds and of the chalk may be found in the gravel beds of which mention has been made. In these we find vast quantities of angular chalk-flints, little rolled or worn, mixed with large quantities of those well-rounded flint-pebbles, which are everywhere characteristic of the plastic clay beds, and are termed by Mr. Prestwich the Woolwich and Reading series.

The bed of gravel upon which the town stands is one of the affluents of the great mass of gravel which

occurs along the valley of the Thames, and it extends in nearly uninterrupted series to the banks of that river, a distance of about twelve miles. Its presence is doubtless due to the same causes to which the present physical geography of the district is ascribed, and which may be shortly described as follows.

It has long been considered by those who have studied the subject, that the Weald of Kent, and Surrey, and Sussex, by which I mean the district lying between the North Downs and the South Downs, is a valley of elevation.

Before this elevation of the Wealden beds, the greensand and the gault and the chalk may have extended over them, and they probably reposed upon each other, in undisturbed and unbroken succession; and possibly they may have been overlaid by the plastic and London clays, although it is doubtful if they extended thus far south. However this may have been, at some very remote period an elevation occurred of all this district by which the Wealden rocks and the overlying greensand and chalk beds were upheaved.

This elevation was doubtless the result of volcanic agencies, in operation, probably, for countless ages, and in the depths of seas which have long since disappeared; and, perhaps, as it took place, the central mass—that along the course of the anticlinal line—was gradually swept or melted away under the long continued action of strong currents. And so that large valley was left, which we now call the Valley of the Weald; while the North and South Down ranges, forming the sides or margins of this valley, being less exposed to the destroying influence which acted upon the central area, were left, like the rafters of a house from which the topmost ridge has been cut or broken off—that on the north side of the chasm dipping to the north, and that on the south to the south.

It is probable that a line drawn from near Alton, in

Hants, passing by Crowborough, to Romney Marsh, would indicate pretty accurately the anticlinal or central line of this great Wealden elevation. Although so far distant, and occurring so many ages since, this great change has left lasting and ineffaceable traces of its influence in the present condition of the town, as well as many others in the county —preparing it, as it were, for the advent of the industrious and prosperous population which was to come in times which then were immeasurably distant.

By means of the slow and long-continued elevation of the Wealden district, the land was gradually elevated on the north, and depressed on the southern extremity of the town; and, from the flow of waters from the slopes of the anticlinal line, the tertiary beds lying above the chalk were swept away either wholly or in part; while the greater portion of the denuded surface became covered with a thick coating of flint-gravel, the ruins of the chalk and plastic clay beds. Nor was this the only result of the Wealden elevation. When the central mass was upheaved, certain lateral or transverse valleys, at right angles with the anticlinal or line of elevation, were formed at various distances, and thus served for channels for the waters to escape from the higher central lands. We find one of these at Dorking, through which the river Mole finds its way; another, at Guildford, forms a channel for the Wey; near Shoreham is a channel for the Darent, and near Rochester for the Medway.

Owing to the permeable character of the soil above Croydon, no river is found to run into it; but if the town can boast of no clear sparkling stream running *through* it, it has an underground river of equal value. The water from the Godstone and Merstham valleys, finds its way under the gravel and sands, and supplies the source of the stream which runs *from* the town, and falls into the Thames at Wandsworth.

It is doubtless owing to the geological conditions which

I have thus attempted to describe, that Croydon enjoys so many sanitary advantages as regards earth, air, and water.

As we have seen, the town does not stand entirely either on the chalk, or the London clay, or the plastic clay and sands, but partly upon each of these beds; and thus enjoys varied and great advantages.

The prevailing winds, which are from the south-west, sweep across a wide extent of chalk downs, and bring with them a full supply of bracing and pure air. The soil is usually so porous that it is altogether free from unwholesome damps; while the great admixture and variety of earths is found to be favourable to the growth of both grass and corn of all kinds; and, lastly, the rain falling on the chalk hills south of the town finds its way through the valleys before mentioned into the beds of gravel and sand on which the town is placed, and being there interrupted by the thick impermeable beds of London clay which underlie the gravel, affords a copious supply of excellent water.

We cannot doubt that the clear springs from which the Wandle here takes its origin attracted the first Anglo-Saxon settlers to the *crooked* or winding valley. Tacitus, in describing the manners and customs of the German races of his time, tells us that they did not live in streets and towns, as the Romans did; but that every one dwelt apart by himself, just as the wood, or the plain, or the fresh spring pleased him.

PAPER ON THE BOURNE OF CROYDON,

BY

C. W. JOHNSON, Esq., F.R.S.

The stream which occasionally, but at very uncertain periods, issues from the chalk hills south of Croydon, is locally known as "the Bourne." It flows down the valley from Caterham, by Foxley-gate and under Riddlesdown, into the Valley of the Wandle.

The Bourne first makes its appearance in a little hollow at Birchwood, by the side of the private road to Marden Park. In the winter of 1860-61 it first came out of the chalk close to an ash tree, but other springs, as usual, soon joined it as it flowed towards the Park Lodge, on the Croydon and Godstone road, and thus a copious bright stream was soon formed, which flowed at the rate of between three and four miles an hour towards Foxley-gate.

These intermitting outpourings are common to the chalk formation. In some places, as at Croydon, Epsom, "the Bourne Mill," near Farnham, and Gatton, they appear at uncertain intervals; in others, as at Lewes, and the Winterbournes in Dorsetshire, they flow every winter.

These remarkable streams are frequently noticed in old chronicles. One of them is noticed in the chronicle of John Werkworth, who flourished in the reign of Edward IV., as one of the "woo-waters" of England—one of those which "Englyschmen muche feared all that tyme thei saw it, senne thei knewe welle that woo was cominge to Englande." It seems they regarded it as a "tokenne of derthe or of pestylence, or of grete batayle." Camden, in his Britannia, remarks, when speaking of Croydon, "For the

torrent that the vulgar affirm to rise here sometimes, and to presage dearth and pestilence: it seems hardly worth so much as the mentioning, though perhaps it may have something of truth in it;" and he also notices another of these bournes near Redbourne, in Hertfordshire, whose outburst also portended "dearth or troublesome times,"—this was called "Meregate," which Bishop Gibson tells us in a note means an issue, or outgate of water. It has been conjectured that the "Earthbourne" of Epsom (anciently Ebbisham) gave its name to the parish, the Saxon words *Ebbe*, meaning the ebb or influx of water, and *ham*, a place or village.

Our ancestors were evidently puzzled to explain the origin of these intermittent torrents—and, even in our time, strange explanations of the phenomenon have been given. It has been suggested that the Croydon bourne issues from some subterranean cavern in the Merstham or Godstone hills, in which the water which has accumulated and been stored up for a lengthened period, at last finds its way out by means of a *siphon*. The objections to this theory, however, are so obvious and so numerous, that it deserves little or no consideration. It is simply impossible that those conditions which are requisite to constitute a *siphon* should ever be found in the interior of a chalk down, if even we could believe that a vast subterranean lake or reservoir should exist in a rock so fissured and broken.

The origin of these bournes is easily accounted for; all the rainfall upon the chalk either evaporates or sinks into the earth,—there is little or no *surface* drainage. In the *summer* months the rain which it receives is almost entirely *evaporated;* there is little or no overplus to feed its springs. But in the autumn and winter months the case is reversed; the *smaller* portion of the rainfall then evaporates; the larger portion descends beneath it.

Whenever the rainfall considerably exceeds the average annual amount, the old streams or bournes are unable to discharge the unusual amount of water with which the

chalk hills are saturated; and this surface water, in obedience to the law of gravitation, makes for itself a new channel. A large portion of the water which flows from the Godstone and Merstham hills usually percolates through the thick beds of porous gravel and sand upon which the town of Croydon is built, and thus finds its way by slow degrees and through various springs into the Wandle, and thence to the Thames. When, however, these beds of sand and gravel, after a very rainy season, are so saturated with this water that they can take no more, that which they cannot receive overflows the usual subterranean channel and appears on the surface, and thus the well becomes a river: the subterranean watercourse is *choked* and filled up with *water*, and that as effectually as if it were filled in with pitch or metal, or any impermeable material: and the water which is thus diverted from the usual channel must of necessity find a new one, which it retains until, by slow degrees, the underground watercourse is restored to its normal condition.

For the better understanding of this interesting question, it may be worth while to consider some important data with reference to the rainfall upon chalk.

The annual average rainfall in Surrey is about 24 inches, or 2,400 tons per acre; of this quantity we learn from some experiments carried on for some years by Mr. Dickenson, on the chalk soils of Hertfordshire, the evaporation by the sun and wind carries off about 14 inches, or 1,400 tons, and about 10 inches, or 1,000 tons per acre, sink into the earth, and are discharged by the springs or other natural drains.

When, however, an unusual fall of rain occurs, say 30 inches of water, during a similar period, a very different state of affairs takes place. 3,000 tons of water per acre now descend upon the land. The *evaporation*, however, remains nearly the same, viz., about 14 inches in depth, or 1,400 tons of water per acre, whilst the *drainage* water is increased from 10 to 16 inches, or from 1,000 to 1,600

tons per acre; an outlet, therefore, is needed, that will convey 600 tons of water per acre more than in years of average rainfall. If the course of the drainage waters of the chalk is correctly given, then it ought to follow that the Bourne at Croydon, and other places of irregular outpourings, should make their appearance soon after any unusual annual rainfall. Now we find that whenever the rainfall in one year is about 30 inches, the Bourne makes its appearance at the close of the year, or early in the ensuing spring; and that whenever the rainfall considerably exceeds 30 inches in the year, as in 1818 (33·4 inches), 1821 (34·5 inches), 1824 (36·3 inches), 1841 (33·3 inches), 1852 (34·2 inches), the Bourne flows copiously.

Year.	Rain.	Flowings of the Bourne.
1815	22·5	
1816	30·1	
1817	29·0	
1818	33·4	
1819	31·1	
1820	26·2	
1821	34·5	Copious
1822	27.7	
1823	27·1	
1824	36·3	Very copious
1825	24·5	
1826	23·0	
1827	24·9	
1828	31·5	
1829	25·2	Moderate
1830	27·2	
1831	30·8	
1832	17·7	
1833	23·0	
1834	19·6	
1835	24·9	
1836	27·1	Moderate
1837	21·0	
1838	23·8	
1839	29·6	
1840	18·3	Moderate
1841	33·3	Copious
1842	22·6	
1843	24·6	
1844	24·9	
1845	22·4	
1846	25·3	
1847	17·8	
1848	30·2	
1849	23·2	
1850	19·7	
1851	20·15	
1852	34·2	Moderate
1853	24·37	Copious
1854	18·92	
1855	24·38	
1856	22·72	
1857	21·06	
1858	15·78	
1859	25·54	
1860	30·08	Moderate
1861	19·23	
1862	26·36	
1863	21·63	Small
1864	17·60	

These returns of the rainfall are taken from the records of either the Royal Observatory at Greenwich, or that of the Royal Horticultural Society at Chiswick. At Croydon the rainfall in 1860 was 31·35 inches.

Certain remarks recently made in the Godstone stone quarries, and during the course of the Bourne, all tend to support this explanation of the origin of the stream. It is probable from these observations that the water found in these quarries is always, even in the driest seasons, flowing by under-ground channels into the Bourne culvert at Croydon. In rainy seasons the water rises considerably in these quarries; but it is found that it is not until they are about two-thirds full, and then contains probably about 14,000,000 gallons of water, that the Bourne makes its appearance near Marden Park. There are thus two channels by which the waters of the Godstone range of hills find their way into the Wandle, viz., 1. The ordinary under-ground course, and when this cannot carry the increased flow of rain-water: 2. The outpouring of the Bourne, by the side of Riddlesdown; and, thirdly, that near Marden Park. In 1860 the Bourne first rose near the side of Riddlesdown in November, but it did not rise at Marden till February, 1861; where at this time it was discharging about 600 gallons per minute; whilst that near Riddlesdown poured forth about 1,400 gallons in the same period. The united streams lost, however, considerably in their course by soakage into the ground, for below Riddlesdown they only flowed at the rate of 1,500 gallons per minute. The water they thus lost evidently descended into the soil, and united with the constant under-ground stream, to which we have already referred, for at the very time that the Bourne water was flowing at the rate of only 1,500 gallons per minute below Riddlesdown, the water from the mouth of the Bourne culvert was pouring into the Wandle at the rate of 3,500 gallons per minute. *(Paper by Mr.*

Braithwaite on the River Wandle, Inst. of Civil Engineers, 1861.)

The composition of the Bourne water is chemically the same as that of the other water of the chalk, but its temperature is rather lower than that of its ordinary springs. On the 13th of January, 1861, the temperature of its water at the very highest point, where it issued from the ground (in a very small stream at Birchwood, near Marden Park), was only 32·8 degrees. About 100 yards lower down, where it first became a noticeable rivulet, it was 37 degrees. Still farther down, where it was flowing under the little culvert at Marden Park-gate, it was 41 degrees. When running through the culvert, nearly opposite Whyteleafe, it was 40·9 degrees. Lower down still, when issuing from the pond, not far from the Rose and Crown Inn, it was 41·2 degrees. Descending still lower down the valley, and evidently becoming more copious as it proceeded, its temperature gradually increased, until, in passing the farm of Mr. Tidy, it was 45 degrees. It was of the same temperature when running opposite the Kenley station. After this the stream, as it proceeded, began to decrease both in volume and temperature. It was only 41·1 degrees on arriving at the farm of Mr. Rowland. Passing this homestead, it entered a meadow, resting on very absorbent gravel, and there it sank so rapidly into the soil that, although a copious little stream on its entrance into the mead, it gradually lessened in amount as it travelled through it, and at last quite disappeared before it had nearly reached the extremity of the field. (Towards the end of February, it had penetrated down the valley to about 100 yards beyond Foxley-gate, the lowest point it reached.) The temperature on the 13th of January, of the last remnant of the stream, was 42·3 degrees. The reported *coldness* of the Bourne water seems, therefore, to be verified by observation; for when the Bourne, after sinking into the

earth at Foxley-gate, and running for nearly two miles through a bed of gravel, was emerging from the mouth of the Bourne culvert at Croydon, it had in its course acquired several degrees of temperature—since then it was 49 degrees. On the same day the water of a well dug in the chalk at Croydon, was also 49 degrees; that in the great well of the Croydon Water-works, 50 degrees.

On the day when these observations were made, the temperature of the atmosphere in the shade was 34 degrees.

The course of the Bourne down the Caterham valley by Purley to Southbridge Lane, especially during its early flow, is through the bed of rough porous gravel, which at the bottom of the valley rests on the chalk, from Caterham to the Wandle. It is only when that gravel becomes supersaturated with its waters, that the Bourne rises to and flows on the *surface* of the ground, and thus in former days was wont to arrive at, and inundate the old town of Croydon. It was to intercept and divert this source of discomfort and disease that the Croydon Board of Health, a few years since, constructed the Bourne culvert—a capacious brick drain, three feet six inches in diameter. This invaluable safeguard to the town, a mile and a quarter in length, at a depth of eight feet from the surface, traverses the bed of gravel to which we have alluded. It extends from the river Wandle under the main street of the old town, through Southbridge Lane, and along the Brighton Road. This great drain, from its lower portion being made with uncemented bricks, rapidly draws the water from the bed of gravel it passes through, and whoever wishes to see how well it performs its work, should mark the large volume of water which, at all times, it pours into the Wandle near the old church at Croydon. Such a visitor, when thus viewing the cold waters flowing away, would, perchance, have usefully suggested to his mind one or two things upon which he had never before

reflected. He might hence be led to remember that there are other great works hidden under the soil in and around the town of Croydon—disease-preventing drains, health-diffusing water mains, that were not long since constructed through the moral courage and forethought of some of his neighbours, in days when such improvements were *not* so generally popular as now.

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