SECTION III.

CHEMISTRY, METEOROLOGY AND GEOLOGY.

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ADDRESS

By William Marcet, M.D., F.R.S.

PRESIDENT OF THE SECTION.

Subject.—"On the Distribution and object of Carbonic Acid in Nature, and its Sanitary relations."—"On the influence of Altitude on the Chemical Phenomena of Respiration."

Part I.

It was first shown by Lavoisier, that whenever coal or charcoal is burnt, the combustion is attended with a combination of carbon with oxygen. From this chemical action there result two compounds, carbonic oxide and carbonic acid, carbonic acid holding twice as much oxygen as carbonic oxide. Carbonic oxide is a gas highly poisonous even in small proportions. It may be seen burning with a blue flame in our ordinary house grates, when the combustion of the coals is incomplete, and in certain manufactures it may be given out in very large quantities. Thus the gas evolved from Iron blast furnaces contains 25 to 32 °/₀ of carbonic oxide. The late distinguished Physiologist, Claude Bernard, has shown that this gas arrests life by destroying the functions of the blood corpuscles; the deleterious effects of carbonic acid are of a totally different character.

Carbonic acid gas takes a part in the phenomena of nature, the extent and importance of which are in general scarcely realised. Volumes of this substance are poured out daily from our house chimneys, and produced by the coals burnt in our manufacturing districts. Man and animals also give out carbonic acid, and reckoning at 8 grains per minute the amount expired by every person, it would follow that the 122,376 inhabitants of the town of Leicester would exhale 139 pounds of this gas per minute.

It is, at first sight, remarkable that carbonic acid gas should not accumulate in the air of those districts where it is mostly produced; and also that being, as it is, heavier than the atmosphere, it should not form into a dense layer on the surface of the earth. That this should not be the case is due to a very interesting property of the gas in question, namely, its diffusibility. By diffusibility must be understood the power the gas possesses of distributing itself throughout the atmosphere. Thus it is, that in a room crowded with people, all expiring carbonic acid at the rate of about 4 per cent. of the air breathed, the gas moving in every direction will spread itself throughout the apartment, so that a cubic foot of air will be found to contain the same proportion of the gas as another cubic foot taken anywhere else in that same room.

Carbonic acid is diffusible not only in air, but also in water under the atmospheric pressure. Sea and lake water contain carbonic acid derived from the atmosphere, indeed it is difficult to obtain distilled water free from carbonic acid; and in a long series of experiments on respiration, requiring the use of distilled water absolutely free from this gas, I was often compelled either to distill the water myself, or boil it, which had the effect of driving off any carbonic acid that might be left in it. The only water naturally exposed to the air in which I could not detect its presence, was on the mountain pass of St. Théodule, at an elevation of 10,899 feet, where I tested water from an ice pool.

It is not a little remarkable that indiarubber, a substance resisting so perfectly the penetration of water, should be no check to the passage of carbonic acid gas. Thomas Graham showed, in 1862, that caoutchouc actually absorbs carbonic acid, and holds it, though by no chemical power. This gas equally finds its way by diffusion through a moist animal membrane, and is given out on the surface exposed to the atmosphere. The passage of carbonic acid from the blood, through the moist tissue of the lungs into the air breathed, is readily and clearly accounted for by this very diffusibility of the gas.

The vegetable kingdom derives carbonic acid from the air much in the same way as a damp membrane, throughout which the gas distributes itself. Our green hedges, our luxurious crops, our trees covered with foliage, all absorb a certain amount of carbonic acid from the atmosphere. This, indeed, must be the main source of the carbon used for the nutrition of plants, a certain amount being probably supplied from the roots. Some plants, such as those growing on rocks, must derive the whole of their carbon from the air, and it is stated by Sachs, in his work on Vegetable Physiology, that the organic matter of terrestrial plants increases in weight in a soil deprived of all organic remains by calcination and washing.

Plants, under the influence of their green coloring matter or chlorophyl, together with exposure to light, fix or assimilate the carbon of carbonic acid and give out its oxygen; while at night, in the absence of sunlight, the process is reversed, and carbonic acid is evolved. When a plant increases in weight and bulk, the assimilation of carbon must be greater than its elimination at night; when no increase takes place, the phenomenon of waste must balance that of supply.

A recent enquiry by Dr. Julius Sachs, of Wurtsburg, has thrown much light on the phenomenon which attends the decomposition of carbonic acid, and assimilation of carbon by plants. According to this botanist, the primary action of plants on carbonic acid is the formation of starch, which, however, cannot take place without the presence of the green coloring matter and the influence of light. Sachs ascertains the rate of assimilation of carbon by determining the amount of starch produced. This he does by subjecting the leaves to a certain preparation by which they are blanched, and then steeping them in a solution of iodine, when they are colored blue; the amount of starch is estimated by the depth of color, varying from blackish blue to metallic black according to its quantity. This test—the author calls Iodoprobe—gives speedy and reliable results.

On examining a leaf by this method, the blue color is seen to appear exclusively in those places which had been colored green, showing that chlorophyl alone can produce starch. The process of the formation of starch in vegetables commences in the morning and attains its maximum in the evening. At the end of a fine summer's day, leaves are literally filled with this substance. At sunset, instead of the starch increasing in amount it undergoes solution, and throughout the night is being carried away by the leaves into the stem. Such is the speed of this function of plants, that by about four or five o'clock in the morning every sign of the presence of starch in the leaves has disappeared; by daylight the formation commences afresh. Thus, leaves which in early morning, before sunrise, were absolutely free from starch gave, two or three hours later, a reaction with iodine of an intensely black color.

If a leaf be placed under a glass bell-jar in the sun, together with a piece of potash to absorb the carbonic acid of the air, the assimilation or formation of starch comes at once to a standstill. In one experiment, after the lapse of an hour, not only had the production of starch ceased, but nearly the whole

of that substance obtained by exposure to the air during six hours had disappeared.

Sachs determined the amount of starch thus formed, by weighing portions of leaves of equal surfaces at different periods of the day, and selected for that purpose the large leaves of the sunflower, rhubarb, and pumpkin. He finally measured the total surface of the leaves of a sunflower and a pumpkin; the former, with 145 leaves, exposed to light an assimilating surface of 1·5 square metre (16·146 square feet), and 116 leaves of the pumpkin measured together 7·3 square metres (100·467 square feet). In a single day of 15 hours the sunflower was found to have produced 36 grammes or 555·5 grains of starch, while the pumpkin with its wide leaves had accumulated no less than 185 grammes or 2854·9 grains of this substance. Starch contains 42 per cent. of carbon, corresponding to 154 parts by weight of carbonic acid. I have calculated that 7371 cubic feet of air, under ordinary circumstances, would be required to yield enough carbonic acid to produce 100 grammes or 1543 grains of starch. Should a pumpkin have added to its substance 2855 grains of starch in the daytime, 13,636 cubic feet of air would have been required to supply the carbon for this starch, assuming of course the atmosphere to have been the only source of carbon in the present instance. This volume of air would be that contained in a very large room, such as a hospital ward, holding ten or twelve beds. It is usually admitted and taught that while the carbonic acid of the atmosphere supplies carbon for vegetable growth, all vegetable matter when dead is returned to the air as carbonic acid, as far as its carbon is concerned, either by undergoing slow oxidation in the process of decay, or by being burnt, or by passing through the animal body as vegetable food.

Although carbonic acid is so very diffusible, it is not found everywhere in the open air in equal proportions. That of the London streets, for instance, contains a little more than is found in the parks. There are, moreover, conditions of the atmosphere which have a marked influence on the proportion of carbonic acid gas it may contain. Thus, rain by washing out the air produces a temporary decrease of carbonic acid in the atmosphere; and the presence of clouds, and especially fogs, exerts a very marked influence on atmospheric carbonic acid.

It has been long known that clouds and fogs increase the proportion of carbonic acid in the air of towns. Dr. Angus Smith ("Air and Rain" p. 52) shows that in Manchester there is more of that gas in air in foggy than clear weather; while Dr. Russell, from a recent inquiry undertaken on the carbonic acid of the open air near St. Bartholomew's Hospital, London, has observed that in the presence of fogs the proportion of carbonic acid in the air of towns may be about three times greater than it is in fine clear weather. This gentleman has kindly allowed me to have the diagram he has published, made into an enlarged lecture chart for the present occasion, and you will see by glancing at it to what extent the proportion of carbonic acid in air varies; increasing in foggy and cloudy weather and falling with a clear blue sky. The obvious reason of this phenomenon is, that in fine weather there is nothing to interfere with the diffusion of carbonic acid, while moisture or clouds or fog, by placing an obstacle to the distribution of this gas throughout the atmosphere will thereby increase its amount in a given volume of air. Indeed, it would appear that a close connexion exists between Climate and the proportion of atmospheric carbonic acid, giving the latter a meteorological character.

The well-known influence of autumn and winter fogs on health, predisposing to asthma and pulmonary inflammation, is not unlikely to be due, more or less, to this accumulation of carbonic acid in air, which must interfere with the interchange of carbonic acid from the blood with the oxygen of the air breathed.

The amount of carbonic acid in air varies in the day and night, being a little larger at night; this, indeed, might have been anticipated, especially in the midst of active vegetable life. Vegetation appears to be greatly concerned with the presence of atmospheric carbonic acid, as according to Prince Zadkiel, M.D., a gentleman known from his writings on Egypt, and to whom I have had an opportunity of referring in my book on Southern and Swiss Health Resorts, the air of the Valley of the Nile holds only one or two parts of carbonic acid in ten thousand, while in the air of the desert there is no trace of this gas.

Air at great altitudes.—The distribution of carbonic acid at various altitudes is a question which has not yet been settled in a satisfactory manner. Carbonic acid being generated from the soil or near the earth, and having more or less moisture or clouds to get through before it attains those dry regions where sunshine reigns supreme, the proportion of this gas in high mountains must change within wide limits. You are aware that in cloudy and foggy weather carbonic acid accumulates upon the surface of the land where it is inhabited, and on such occasions we would of course expect to find less of this gas in the higher than in the lower atmosphere; on the other hand, after heavy showers it might be inferred that carbonic acid gas would occur in excess in the regions above the clouds. Carbonic acid has actually been found by some chemists in higher and by others in lower proportions on high mountains than in the plains. According to the Brothers Schlagintweit and Professor de Saussure, it is in excess in high mountains; but more recently M. Truchot (Cpt. rends de l'acad., v. 77, 1875) has arrived at a different result. In this instance the carbonic acid was determined nearly simultaneously at Clermond Ferrand, 1,296 feet above the sea, at the summit of the Puy de Dome, 4,744 feet, and at the top of the Pic de Saucy, 6181 feet. The proportions of the gas in 10,000 feet of air, reduced to the freezing point and seaside pressure, were found to be as follows:—26th, 28th, and 30th August, Clermond Ferrand, 3·13 parts; 27th August, summit of Puy de Dome, 2·03 parts; 29th August, summit of Pic de Saucy, 1·72 parts. Showing a rapid decrease of the proportion of carbonic acid in air on ascending above the sea level.

It is therefore not improbable that just as the amount of carbonic acid near the sea level, or on the low levels of the earth, may vary to a considerable extent, so can it also be greatly modified on high mountains, causing the gas to be at times greater and at others less in the higher than in the lower atmospheric regions.

Sea Air.—As there is no direct source of carbonic acid over the sea, and as water absorbs carbonic acid, though in small quantity, especially when holding salt in solution, sea air might be expected to contain less carbonic acid than land air. A paper by Mr. T. E. Thorpe (Journ. of the Chemical Soc. of London, 1876) gives us interesting and valuable information on the subject. He finds the mean quantity of carbonic acid in the atmosphere of the Irish sea to be (from 26 experiments) 3·082 in 10,000; in that of the Atlantic (from 50 experiments), 2·953 the mean of 77 experiments being 3·00. If land air contains, as is usually admitted, 4 parts in 10,000, there is considerably less carbonic acid in sea air. It appears, moreover, that the carbonic acid in sea air experiences fewer and far less extensive variations than in land air. Its proportion is nearly the same in different latitudes, and is constant in the same locality throughout the year. Although a difference is known to exist in the diurnal and nocturnal proportions of carbonic acid of land air, Thorpe states in his paper that no such difference is to be discerned in sea air. The average carbonic acid in sea air during the day was found to be 3·011, and during the night 2·993 in 10,000.

Sanitary Relations of Carbonic Acid.

According as the carbonic acid in the atmosphere increases beyond its normal proportion, say 0·04 per cent., air becomes less and less fit for respiration. An idea of the extent of the accumulation of carbonic acid in the atmosphere may be formed from the investigation of Mr. Weaver, of this town, who found 0·53 volumes per cent. of this gas in the room of a frame-work knitter in Leicester; in other work-rooms the amounts were 0·52 and 0·46, down to 0·211 (Parkes' Hygiene). The figures between 0·53 and 0·46 would represent about ten times the normal proportion of carbonic acid in the open air. It was thought until lately that this gas acted as a poison, but "Paul Bert," and other physiologists, have shown that such is not actually the case. I have stated, in an earlier part of this address, that in the phenomenon of respiration, carbonic acid diffuses from the blood through the substance of the lungs into the air of the bronchial tubes. Air on the point of being expired contains about 4 per cent. of carbonic acid, that is, a hundred times more than when inhaled, and is therefore very impure. Supposing the air breathed to hold 4 per cent. of carbonic acid, nearly as much carbonic acid would be absorbed by the blood as the blood would emit, consequently that gas would rapidly increase in the blood and produce asphyxia, by checking the phenomena of oxidation. A positive morbid effect is produced long before such a proportion of the gas is reached. Dr. Angus Smith, after confining one or more persons in an air-tight chamber, and analysing its air, expresses himself thus: " . . . but leaving out all the details, the great broad fact remains, that carbonic acid and other emanations from the person diminish the circulation and hasten the respiration, so that the effect is perceptible in a very short time when the percentage of carbonic acid reaches 0·18 per cent. or say, one-fifth of 1 per cent."

When the carbonic acid of the air breathed in Dr. Smith's air-tight chamber attained 3 per cent., the pulse became so weak that it was difficult to count the beats; moreover, a very unpleasant feeling was experienced. On one occasion, the carbonic acid in the air chamber increased to 3·9 per cent., and the Author remarks: "My breathing rose up to 26 inspirations, and my pulse became so weak as to cause alarm."

According to Paul Bert's experiments, small birds confined in a bell jar under the ordinary atmospheric pressure cannot keep alive when the air contains 14·6 parts of carbonic acid for 3·5 parts of oxygen, or say, 4 times more carbonic acid than oxygen. In Angus Smith's experiments, a person subjected to an atmosphere containing 3 per cent. of carbonic acid obtained from his own breath at the expense of the oxygen of the air inspired, would be breathing air holding six times more oxygen than carbonic acid, while pure air would contain 525 times more oxygen than carbonic acid.

Professor de Chaumont, the distinguished President of this Congress, in an interesting paper to the Royal Society, stated, as the conclusion of a large number of observations and experiments, that the proportion of carbonic acid in air can be estimated, within certain limits, by the sense of smell. Thus, a room holding air, "fresh," or not sensibly different from the external air, would contain an excess of 0·2 per 1,000 over the normal amount of carbonic acid in the atmosphere. A room rather close, or in which the organic matter begins to be appreciated by the senses, would contain 0·4 per 1,000 in excess of normal air. Air close, or where the organic matter feels decidedly disagreeable, would contain 0·6 per 1,000 in excess of common air. While air extremely close would hold 0·85 per 1,000 in excess. The relative values of carbonic acid would be: to air fresh, 1; rather close, 2·13; close, 3·46; extremely close, 4·66.

Experiments having important sanitary bearings were made by Claude Bernard in 1857. He has observed that birds can live when accustomed by degrees to breathe air more and more unhealthy by admixture with carbonic acid, while other birds, in perfect health and taken from the open air, when subjected to this same bad air would die either at once or very rapidly. It follows that animals weakened by exposure to impure air are less in want of air holding its full proportion of oxygen than healthy animals. The practical bearing of this experiment is very obvious, and it explains how people living in small, insufficiently ventilated dwellings, and having to keep their windows always closed against the cold air can apparently be doing well. This satisfactory condition is, however, a delusion and a snare, and the fact of the inmates of such houses withstanding impure air with apparent impunity must be owing to a weak state of health, that same air being unfit for persons of a strong and robust constitution. This also explains how people of advanced and sometimes of middle age require less fresh air for the enjoyment of health than others in the full possession of youth and strength.

I happened many years ago to meet with an opportunity of observing on myself the ill effects of the inhalation of carbonic acid gas. This was at an establishment of mineral baths, containing a large excess of carbonic acid gas. When the immersion lasts but a short time, say from ten minutes to a quarter of an hour, no ill effects are produced; indeed one is conscious of a rather pleasant titilation, as gas bubbles form and break on various parts of the body, but should the bath be prolonged unpleasant symptoms may follow. I distinctly recollect that after an immersion of twenty or twenty-five minutes, I got out and dressed, though with the greatest difficulty, feeling very giddy and hardly able to stand. It took me a long walk before I could be rid of the effects of the bath, which were clearly due to the carbonic acid inhaled while in the water.

PART II.

On the Influence of Altitude on the Chemical Phenomena of Respiration.

From the circumstance that man is apparently destined to live in the plains and near to the sea level rather than on high mountains, any change of altitude will be more liable to bring him under the influence of diminished rather than increased atmospheric pressure. On ascending even but a few hundred feet, an exhilarating sensation of freshness of the air and of comfort in the act of breathing will generally be experienced; this I noticed one day as I was walking up to Les Avants, from Montreux, near the Lake of Geneva. I was then trying to make out at what height the exhilarating effect of increasing altitude would first be experienced, and found it to be about 500 feet above the lake. Most people can live comfortably in the Alps up to 5,000 or 6,000 feet; the temperature and degree of humidity of the atmosphere having apparently much to do with this kind of acclimatisation. On the rocky mountains of Colorado there are many towns 10,000 feet high, where from personal experience I can say that no inconvenience is felt from the lightness of the air, except, perhaps, at times when running or taking active muscular exercise in other ways. The air in that country is warm in summer in the daytime and very dry. On the other hand, the monks of the grand St. Bernard, who live in a damp and cold climate at an altitude of 8,115 feet, suffer much on that account. Though all of them young men, and selected as to fitness to stand rough and cold weather, most of them after a year or two suffer from rheumatism and derangement of the stomach, and have in consequence to leave the spot. It is remarkable that very few become consumptive, though bronchitis is frequent among them. This information I hold from the monks personally.

For the successful ascent of high mountains the principal condition is "training." Climbing has this advantage over balloon ascents that the rise is much more gradual and the functions of the body have time to accommodate themselves to

the change of pressure. A balloon not unfrequently makes a rapid start upwards, the change of pressure being so sudden that it may produce evil and even serious effects, where a gradual ascent would have been unattended with danger. The well-known ascent where Messrs. Sivel and Croce Spinelli lost their lives, probably proved so fatal on account of the great speed the balloon had acquired.

The particulars of this unfortunate expedition are related in the "Comptes rendus de l'académie" for 1875, by M. Tissandier, the only survivor of the three aeronauts, and a short abstract of this personal narrative might not be uninteresting on the present occasion:—

"The atmosphere exhibited on the 15th of April a peculiar condition. At 4,100 metres (14,763 feet) we floated on the level of light cirrhus clouds, at 7,000 metres (22,966 feet,) the car was surrounded by cirrhus, with an atmosphere full of crystallised particles. At this altitude of 7,000 metres no alarming symptoms had been shown by any of us, but at 7,500 metres (24,606 feet), Croce and Sivel were pale, and the latter, of a sanguine temperament, closed his eyes at times. At 7,000 metres we breathed repeatedly air containing 70 per cent. of oxygen gas, and were refreshed by it.

"At an altitude of nearly 7,500 metres (24,606 feet) we were motionless in the car, and certainly benumbed. Sivel then emptied three bags of ballast in order to reach and rise beyond the altitude of 8,000 metres (26,247 feet) which we had proposed to attain.

"From my recollection, which is very clear, of the benumbed state in such an altitude, the mind and body become by degrees weakened, though unconsciously; the dangers of the voyage are no longer contemplated, there is a knowledge that the ascent is progressing, and this is attended with a pleasant feeling. I soon felt so weak that I could not even turn my head to look at my companions; I wished to lay hold of the tube of the oxygen bag, but could not possibly lift up an arm. My mind is still however very clear; I continue observing the index of the barometer and read 280, which is rapidly exceeded. I wish to call out 'we have reached 8,000 metres,' but my tongue is paralysed. Suddenly, at 1.30 p.m. I shut my eyes and fall, losing all consciousness. At 28 minutes past 2 I awoke, the balloon was descending. I emptied a bag of ballast to check the speed, and could write a few lines in my note book, recording a pressure of 315$^{m.}$ (7059 metres), temperature—8°.

"A few minutes later Croce Spinelli, also recovering consciousness, seized my arm and called my attention to the fact that ballast must be turned out; he ejects it himself. The balloon, very hot and air-tight, rose once more into those high regions from whence it had just descended. The valve should have been opened, but none of us was strong enough to do so; I then lost consciousness a second time.

At 3.30 I became able to observe the altitude which was 6,000 metres (19,685 feet). Croce Spinelli and Sivel were laying dead in the car. The subsequent examination of the barometric tubes showed that the pressure had fallen to 264 and 262 millimetres, which brings the maximum elevation to 8,540 metres (28,019 feet), and 8,600 metres (28,215 feet)."

Tissandier adds to the above narrative that he feels certain Croce Spinelli and Sivel would have survived had they been able to breathe oxygen.

Mr. Glaisher, in his memorable balloon ascent, lost consciousness at 29,000 feet, so that both parties appear to have attained the limits of respirable air.

From the above it will be seen that the respiration of oxygen gas when the air has become too light to keep up animation can, at all events for a time, maintain life. Chlorate of potash is a substance which, when heated, gives out oxygen, and is indeed used for the preparation of this gas; it is, moreover, largely employed in medicine. When Mr. Edward Whymper left for his well-known exploration of the Andes, I had occasion to suggest to him the advisability of taking out some chlorate of potash, to be used in case of need against the ill effects of deficient oxygen at great altitudes. I had been told by Sir Douglas Forsyth that when crossing the mountains of Cashmir on his way to Cashgar, at a height of 19,000 feet, he had found much benefit from the ingestion of this substance, when affected by the lightness of the air, hence my suggestion to Mr. Whymper. This gentleman made use of the medicine on several occasions, and informed me subsequently he had derived much relief from it.

It is very difficult to assign the altitude man and animals can reach. Interesting observations by Mr. Paul Bert on the influence of low pressures on animals show that they can live under pressures of 210 to 230 millimetres (8·268 to 9·055 inches), and that if instead of the pressure being reduced quickly, animals are gradually deprived of air, it is possible to extend the limits of life to 170 or 180 millimetres (6·693 and 7·087 inches).

On the occasion in which Messrs. Sivel and Croce Spinelli lost their lives, the rate of ascent was very rapid, and consequently the aeronauts were under the worst possible conditions to stand such a great fall of pressure; they lost their lives when the barometer had reached 10·394 inches, which corresponds to an altitude exceeding but slightly the limits established by Paul Bert from his experiments. High mountains are climbed under circumstances very different from those attending a balloon ascent. The immobility to which a person is subjected in the car of a balloon, added to the very low temperature of the air at great altitudes, are productive of a sensation of numbness and sleepiness, while the fall of pressure must add to the feeling of cold by diminishing the supply of oxygen for respiratory purposes. Moreover, the evaporation from the skin and lungs in the very dry air of the upper regions, must be attended with a corresponding production of cold, hence most circumstances unite to lower the temperature of the body, and consequently depress the circulation. On ascending high mountains the conditions are entirely altered. When about 10,000 feet high are reached the progress becomes in general much slower, and most climbers, unless strong and in excellent training, have to stop every few minutes to take breath. Mountain sickness often occurs at that altitude, and is in many cases an obstacle to any further progress. The main precaution to take in order to reach great heights is to move on slowly. It took many days for Mr. Whymper, and many long halts, to reach the summit of Chimborazo (20,517 feet).

In the season 1855-56, on the occasion of the magnetic survey of India, the brothers Robert and Adolph Schlagintweit achieved a brilliant series of explorations and ascents. They remained ten days on the slopes of the great Gurhwal peak Ibi Gamin (25,500). Every bivouac during that time was about 17,000 feet, the highest reaching to an altitude of 19,326. Finally they ascended to 22,239 feet, which for a long time remained the extreme height attained.

In 1864 Mr. Johnson is reported to have climbed up to a ridge in the Ladak (Himalaya) which exceeded 22,300 feet, and in the following year he is said to have reached a height of 23,728 feet. Mr. Graham, and a Swiss guide in 1884, first rose to an elevation of 20,000 feet in the Himalaya, then 22,700 feet close to the summit of the Dunaghiri, which he unfortunately could not attain, though within 500 feet, on account of mist and hail. The greatest achievement of Mr. Graham and his Swiss companions Kauffman and Boss, was their reaching, according to his statement, the summit of the Gaben at least 23,700 feet above the sea.

While mountaineering in the Alps, it occurred to me that a careful investigation of the influence of light mountain air on the chemical phenomena of respiration might yield very interesting results. There was reliable information to be obtained in various published sources, on the general influence of altitude on breathing, the most extensive perhaps being that of Dr. Jourdanet, who resided for many years in Mexico; but I could find no reliable work dealing with the actual chemical changes brought on by removal from a lower to a higher altitude.

In the year 1875 I tried various contrivances of a portable description to collect a definite volume of air expired, and submit it to analysis by Pettenkofer's process. Finally, a glass cylinder was adopted of a known volume, and an account of the process was published in the Journal of the Chemical Society for 1880. The cylinder is closed at both ends by glass plates, screwed down tightly, and a vacuum is obtained in it by means of a portable air pump. The air, after having been expired from the lungs into an indiarubber bag, is let into the vessel, and fills exactly the cylinder under the atmospheric pressure; thus a known volume of air from the lungs is collected to be submitted to analysis. I completed over 400 analyses of this description, the air having been expired at altitudes varying from 1,000 to 13,685 feet in the Alps, and from the sea-side to 12,000 feet on the Island and Peak of Teneriffe. A last series of experiments, made in 1883, has not yet been published, but it confirms in every respect the results previously obtained.

Before entering upon the account of my own work, I must acknowledge the investigation on the same subject of a Swiss gentleman, Mr. Mermod, who experimented on two stations in Switzerland, varying only from 1,100 to 3,202 feet; his results were published in 1877; he found the carbonic acid expired within a given time to be greater at the higher than the lower station, and that the volume of air expired, also in a given time, at the higher station, reduced to freezing point and sea-side pressure, was less than at the lower station; but he went no further. I shall have an opportunity of showing that these results, though correct as far as they go, do not admit of being generalised sufficiently to account for the real influence of altitude on the chemical phenomena of respiration.

In 1876 I ascended, with four porters carrying my instruments, to the well-known St. Théodule Pass, at an altitude of 10,899 feet, leading from Zermatt to Aosta, and remained there eight days, going up the Breithorn (13,685 feet) on three different occasions during that time. The results from this first series of experiments were not altogether satisfactory, and had to be considered as an introduction to subsequent researches.

In the summer of 1877 I experimented at the Hospice of the Grand St. Bernard (8,115 feet), at the Riffel Hotel, Zermatt (8,428 feet), again at the St. Théodule Hut (10,899 feet), and at the summit of the Breithorn (13,685 feet).

In 1878, wishing to be free from the influence of cold at increasing altitudes, I made a journey with all the requisite instruments to the Island of Teneriffe, and spent three weeks on the Peak. On that occasion I selected three stations: one at the seaside, one at an altitude of 7,090 feet—where I camped out eleven days—and one near the summit of the Peak at 10,700 feet, where I remained ten days. The height of the Peak of Teneriffe above the sea is 12,200 feet.

In 1880 I returned into the Alps accompanied by a young friend, a scientific man, and we both submitted to experiment. On that occasion leaving Geneva, where a preliminary series of experiments had been made, we proceeded first of all to Courmayeur, at the southern foot of Mont Blanc, which was our second station, and finally we spent three days on the summit of the Col du Géant (11,030 feet), sleeping in its lonely hut. On that occasion three porters carried up my instruments, one of the cases weighing rather over 80lbs.

In 1883 I made a fresh series of experiments, being accompanied by another young gentleman, an engineer, also perfectly reliable as to the part he took in the experiments. We carried on the work both at Geneva and on the Righi, the Righi Staffel Hotel (5,230 feet), having selected this station in order to obtain the effects of altitude at the usual elevation of an Alpine sanitarium. As already stated, the results obtained confirmed those arrived at from the other experiments. Thus my investigations ranged over the period extending from the year 1876 inclusively, to 1883, being made in the summer time, one season only excepted.

The results I have obtained may be divided into two series; the first applies to altitudes in which a person can live in perfect comfort, and therefore adapted to the maintenance of health; the second series applies to elevations incompatible with the normal functions of the human body. As these altitudes vary considerably according to individuals, it is difficult to define them. I should say, however, roughly, that people dwelling in the plains or near the sea level may live comfortably for months or perhaps years, at altitudes not exceeding 6,000 or 7,000 feet in the Alps. In countries where the weather is generally warm and dry in the daytime, such as the Rocky mountains of America, or the mountains situated between the tropics, much greater altitudes may be inhabited by residents of the plains. Indeed there is no doubt but that, after a time, in certain climates, the body can accommodate itself to the influence of altitudes much above 10,000 feet.

The results from this long-continued investigation were as follows :—*

1. Persons rising above the sea in the Alps, or in northern latitudes where cold may be considered as increasing with the altitude, expire as a rule a larger amount of carbonic acid as they ascend.

2. In hot countries, near the tropics, such as the Peak of Teneriffe, where cold does not become greater on ascending, or at all events not appreciably to the senses, there is no increase of carbonic acid in relation to height above the sea, the amount of this gas I expired per minute having been nearly exactly the same at every altitude. In the case of my companion, a Swiss guide, the maximum expired was at the lowest station, while at the two highest he expired as nearly as possible the same amount of this gas. The excess given out at the seaside in his case was probably due to an increased amount of food he took at the time.

3. It follows, from the above results, that any increase of carbonic acid expired in the Alps must necessarily be due to the fall of temperature of the atmosphere, and in no way to decreased atmospheric pressure.

4. At altitudes incompatible with the maintenance of the healthy functions of the body, whether this be due to cold or to the actual lightness of the air, or to want of training, the amount of carbonic acid expired within a given time is lessened. This was clearly the case with myself and my young friend during our stay of three days on the Col du Géant, at an altitude of 11,030 feet

5th. At increasing altitudes, whether this be in a cold or hot climate, or whether the altitude be incompatible or not with the healthy maintenance of all the functions, I have found it an invariable rule that less air reduced to seaside pressure and freezing point is expired for the same amount of carbonic acid; or, in other words, the body required the inhalation of a smaller weight of air to produce the same weight of carbonic acid. I can offer only one of the two following explanations to this phenomena :—either as the air becomes lighter, the oxygen finds its way more readily through the substance of the lungs into the blood than under a heavier atmosphere; or else an alteration takes place in the blood under a low atmospheric pressure, increasing in amount that constituent of the blood corpuscles which is known to take up the oxygen of the blood, or "hæmoglobine." Such a change in the blood actually appears to take place after a time at relatively great altitudes, as Mr. Paul Bert has discovered that the blood of animals sent from Mexico, or 7,470 feet above the sea, when shaken with oxygen gas produces much more carbonic acid than that of animals of the same description but living in Paris, which he ascribes to an increase of hæmoglobine. It is impossible, however, to tell how long this constituent of the blood would take to increase from the influence of altitude; generations might be required, or the change might occur in a comparatively short time. It seems hardly possible, however, that the composition of the blood corpuscles should thus alter in a single mountain excursion, and the other alternative, that oxygen in mountain air finds its way into the blood more readily than oxygen in air nearer the seaside because of its lightness, appears to me to account satisfactorily for the phenomenon.

* Proceedings of the Royal Society, 1878, 1879.

This result goes far to explain the salubrious effects of mountain air, it shows how persons debilitated by fevers, and indeed most diseases, recover their health in a very short time on a mountain station, and how invalids, with a portion of their lungs incapacitated to do its work, can obtain in mountain stations the amount of oxygen their body requires for the restoration and maintenance of health. It also explains how climbers can reach such altitudes as 21,000 or 22,000 feet, although they should have to breathe air extremely rarefied: this rarefied air yielding its oxygen to the blood much more readily than air under a higher pressure.

On "The Valley of the Soar," by JOHN D. PAUL, F.G.S.

If we wish to study any large tract of country from a sanitary point of view, we must abandon its division into parishes and counties, and look at it as a collection of river basins. The quantity and quality of the surface and underground waters in these basins, the nature of the soil and of the beds beneath it, and the elevation of the surface above the sea, are all powerful influences for good or bad upon the health of the inhabitants. Your Committee have decided that this section might with advantage devote a few minutes to the study of the river valley in which we find ourselves to-day.

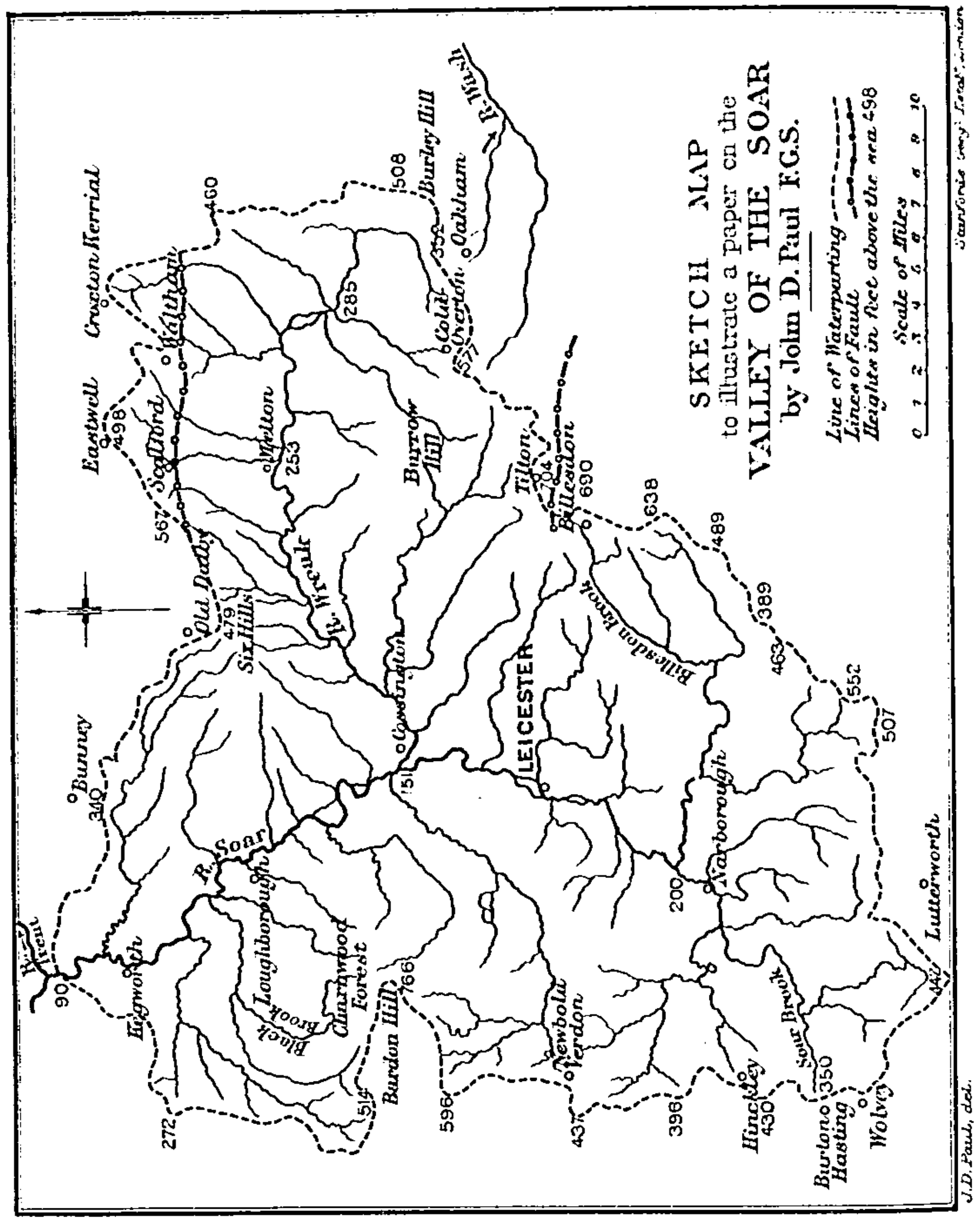
The river Soar,* from its junction with the Trent at Kegworth, measures in length about 34 miles, and drains an area of about 550 square miles. It flows through the middle of the valley, and at Cossington receives its only important tributary, the Wreak. If we follow the course of the river from its junction with the Trent down to Narborough, and then pass south to Lutterworth, we shall find that on the west of this line the surface is composed of Keuper Marls, except where the rocks of Charnwood Forest rise in a miniature mountain chain; whilst to the east we have first a narrow strip of Rhœtics, and then the Lower Lias Clays reach to the margin of the valley. All the beds dip gently towards the south-east. A small coalfield lies beneath the Keuper, south of Charnwood, and extends down to Hinckley, but it has not at present been traced far over the boundary of the valley. The Lower Lias beds yield the excellent Barrow Lime. Along the eastern edge of the valley ironstone is obtained in large quantities from the Marlstone and the Northampton Sand. The Syenites, which break through the flanks of the Forest rocks and crop out as far south as Sapcote, are largely worked for road metal. In the district are found the gypsum of the Upper Keuper Marl, and the brick clays of the drift, a vein of lead ore in the Waterstones, and some traces of tin in a brook on the Forest.

The shape and extent of the valley have been determined:—

First, by the hard boss of the volcanic rocks of Charnwood Forest, which lie to the west of the river at Loughborough. Though these rocks have been considerably lowered by denudation, still no watercourse has been able to cut its way through them.

Secondly, by the ridge we have spoken of before as running along the northern boundary of the valley from Kegworth to Croxton Kerrial, with its backbone of hard Marlstone rock, which has resisted the denuding agents that have excavated the valley of the Trent on one side, and on the other the valley of the Wreak in the softer clays of the Lower Lias. The

* For the derivation of the word Soar, see Fergusson's "River Names of Europe," p. 54:—"There can hardly be a doubt that the words sar, sor, sur, so widely spread in the names of rivers, are to be traced to the Sanscrit sar, seri, to move, to go; sru, to flow; whence saras, water; sarit, srota, river. The Permic and two kindred dialects of the Finnic class have the simple form of sor or sur, a river. France, the Serre joins the Oise. Germany, the Sarre, also the Sure and the Sur. Switzerland, Sare and the Sur. Norway, the Sura. Russia, the Sura joins the Volga, the Svir falls into the Lake Ladoga. Portugal, the Sora joins the Tagus." The origin of the name Wreak is more difficult to trace. The Basque word erreca, a brook, may be connected with a root which has been well-nigh lost, but from which the Irish earc, water, has descended, and of which the Wreak may be another representative.



descent of the spur of Marlstone Rock in this ridge to the level of the Lower Lias Clay, is caused by a fault which we can trace for 12 miles along its edge, and this has been one of the main causes that have given to the Soar Valley its present shape. Any one who will examine the map (p. 264) will, I think, admit the great probability that this ridge at one time extended across, by way of Six Hills, Prestwold, and Loughborough, to the Forest. If it did so, one of the first steps towards the formation of the Soar Valley must have been the commencement of a watercourse draining northwards at the foot of the Forest hills. Where we have an elevated rocky district draining towards a more easily denuded country, we usually find a river running near the line of contact of the harder and softer beds, just as we have the Severn flowing at the foot of the Malverns.

Third. Continuing our circuit round the margin of the valley from Croxton Kerrial to Billesdon, we follow the water-parting running along the edge of the escarpment formed by the Marlstone and the Northampton Sand which overlie the thick and easily denuded clays of the Lower Lias. The same escarpment forms the eastern side of the valley of the Severn, and near Cheltenham attains a height of 1,100 feet. It may be traced, varying in importance with the number and thickness of the beds which compose it, across the kingdom from Bristol to the mouth of the Humber. As we stand on its summit by Billesdon, Burrow, or Cold Overton, at a height of about 700 feet, and look across to the Forest, we see the valley of the Soar as an outstretched plain lying several hundred feet beneath us.

We ought not to leave this corner of the valley without noting the very striking breach which occurs in this escarpment at Oakham. It presents an unbroken elevation till we come to Burley Hill which is somewhat over 500 feet high, when for two miles in width an immense gap has been cut through it. If we pass through this gap towards Stamford, we find ourselves in a deep, wide river valley, which must have required the scour of a considerable stream to hollow it out. Now at Oakham there is no river, and between Langham and Burley there is not even a brook, and if we wish to account for the immense amount of work which has obviously been performed, we must suggest some conditions very different to those prevailing at the present time. So far from this requirement placing any difficulty in our path, the explanation we are obliged to suggest is really a very striking confirmation of the history of the formation of the valley which we have been endeavouring to make out. We have spoken of the gradual excavation of the soft, easily denuded Lias Clays, and the consequent extension of the valley of the Soar eastward up the area at present drained by its tributary, the Wreak. When that process of eastward extension commenced, what is now the valley of the Wreak must have been filled up with a mass of Lias Clay, Marlstone, and Oolite, several hundred feet thick, the surface of which sloped towards the east. Down this slope, past Oakham, flowed the surface water on its way to the sea, cutting the channel of the river Wash between Oakham and Stamford. Every addition to the water of the Soar which reaches it by the Wreak, is just so much robbed from the Wash; and this valley, which is to-day tributary to the Soar, was at one time the gathering ground of the head-waters of a stream which cut the gap at Oakham through the Oolite and Upper Lias Clay down to the Marlstone Rock.

When we leave the floor of the valley and ascend the escarpment we have before referred to as forming the margin of the valley on the east, as for instance at Burley Hill, we pass from the Lower Lias Clays, which are here covered with thick patches of drift, the remains of what was at one time probably a continuous sheet banked up against this rim of the basin, and as we mount the hill we come in succession upon the Middle Lias Clays, the Marlstone Rock bed, the Upper Lias Clay, and last of all we have the capping of Northampton Sand or Ironstone. An advance of a few hundred yards further along this high tableland, brings us upon the Lincolnshire Oolite, which covers the country for some miles to the east. South-west of Oakham this plateau has been subjected to a more active denudation than between Oakham and Croxton Kerrial, and the Lincolnshire Oolite and Northampton Sand have been removed from about thirty square miles of high country lying between Oakham and Tilton-on-the-Hill.

Passing along the escarpment, at Billesdon we meet with a fault which repeats the condition of that we have already referred to as running by Scalford and Waltham. In the same way it brings down the Marlstone to the level of the Lower Lias Clay, and permits the excavation of a valley on its southern side, which in this case is tributary to the Welland, whilst at the same time it forbids the extension of the Soar valley lying to the north. Just before the water parting quits the top of the escarpment, the springs from the Marlstone give rise to the Billesdon brook, one of the secondary tributaries of the Soar. As the water parting sweeps round the southern edge of the valley past Lutterworth, Hinckley, and so on to Newbold Verdon, it descends 200 or 300 feet, and passes over a country, first of Lias Clay and then of Keuper Marl, which is encumbered with masses of drift, sand and gravel, which may

indicate the beach of a glacial sea. The roll of high land which separates the drainage areas of the Anker, the Sence, and the Mease, tributaries of the Trent valley to the west, from the valley of the Soar, has doubtless been preserved by the protection afforded by the Forest Hills against denuding agencies descending from the north.

From these beds of sand and gravel issue the springs which give rise to the minor brooks which come together in about the centre of the valley near Narborough. One of these, called the Soar brook, is entitled to some attention, as it is the source of the river. About two miles south of Hinckley, on the road to Wolvey, at a height of 350 feet above the sea, there is a large patch of eastern drift sand and gravel lying in a pan of retentive clay. It is just outside the county boundary, and formed, years ago, part of the common fields of Burton Hastings, in Warwickshire. Between three mounds, covered with gorse and trees, which may have been ancient burial places, runs a ditch only a few inches wide, but so well supplied with water from the bed of sand that it is overgrown with reeds, which before the enclosure no doubt spread over several acres, and formed a home for snipe and waterfowl. This ditch is the source of the Soar. During its course of ten miles and a half, down to Narborough, it falls at the high rate of 15 feet in every mile; whilst from Narborough to the Trent the gradient is 5 feet to the mile. It is only the comparatively small quantity of water which descends by these brooks in the upper reaches of the Soar that deprives them of considerable denuding power, and so prevents the rapid extension of the valley to the south.

There is a fourth physical feature without which the Soar Valley could never have existed in its present form, and that is the very marked depression which crosses the centre of England, between the southern end of the Pennine Chain and the high ground lying to the north of Charnwood Forest. By this depression the Trent, after draining a large part of the counties of Stafford, Warwick, and Derby, finds its way across the centre of the kingdom: at its junction with the Soar at Kegworth it is only 90 feet above the level of the sea.

Turning our attention now to the interior of the valley, we cannot fail to be struck by the nearly uniform height of the hills on either side of the river; and if we imagine a line reaching from one edge of the basin to the other, touching the tops of the hills, we should find it raised about 300 feet above the level of the sea, over the river Soar, and rising one or two hundred feet higher as it approached the watershed on each side of the valley. The height and slope of this line give us an indication of the position and the inclination of the floor of the glacial sea, beneath which the valley was submerged. The patches of drift, sometimes 100 feet thick, to which we have so frequently referred, are the remains of the materials which made up this ancient sea bottom. Through this floor of tough glacial clay the water courses, and the river valley have been excavated by the action of rain and weather. We have abundant evidence that after the main features of the valley had been sculptured into very much their present form, that it again descended beneath the waves of a glacial sea, though apparently for a shorter period. Along the eastern side of the valley the junction of the Marlstone Sand and the Northampton Sand with the impervious Lias Clays is marked by a line of springs which has determined the sites of most of the villages on that side. The Lias Clays are almost destitute of underground water, and the villages dotted on their surface derive their supply from patches of the drift. The same may be said of many of the towns and villages on the Trias. As an instance I may refer to Hinckley, where all the wells are sunk in the drift gravel.

An examination of the basin of the Soar shows that there are several areas from which the 150,000 people collected round Leicester in the centre of the valley may draw any further water supply they may require. The Thornton, the Swithland brooks, and the Blackbrook, which have been already appropriated, are unquestionably the best collecting grounds in the valley, but there are others, such as the Twyford and Billesdon brooks, which might be drawn upon for additional supplies. Unfortunately the underground waters, such as those from the Waterstones, give little promise of a supply suitable for domestic consumption.

There is always an abundant supply of brilliant water ready to burst from beneath the gypsum beds in the Upper Keuper Marls, and this source has been drawn upon in many cases in Leicester by the owners of steam engines for condensing purposes. The water, which is reached at about 30 yards, contains about 100 grains of sulphate of lime and 20 grains of sulphate of magnesia to each gallon. This supply is worthy of more attention than it has hitherto received. In the Waterstones still lower down in the Keuper, is stored up a large supply. At Hinckley the local authorities bored down 750 feet through the gypsum beds and the saliferous marls to the Waterstones, with the result that they obtained an ample supply of water, which contained 650 grains of solids to the gallon, consisting of 340 grains of sodium sulphate, 163 of calcium sulphate, and 101 of sodium chloride, with 31 of carbonate, and 11½ of sulphate of magnesia.

Turning our attention now to the river itself, I find that the water is of a better quality than one might expect. Dr. Emmerson, the County Analyst, has kindly furnished me with some particulars of a sample recently taken, after a period of comparatively dry weather, from below the Bow Bridge. It contains 49·5 grains of solids to the gallon, chiefly carbonate of lime, with some sulphates, whilst the amount of free and albuminoid ammonia only amounts to one-hundredth part of a grain. The hardness is 8½ degrees.

The river has excavated for itself a wide valley in the Upper Keuper Marls, and beneath the meadows on either side of the present channel we have a regular series of deposits. Lying in a pan of hard Keuper Marl we have first a varying thickness of rolled gravel, doubtless the remains of the mass which has been removed in the formation of the valley, the marl and sand having been washed away by running water, and the stones left behind in the bed of the stream. On the top of this gravel we find several feet of clay, brought down into the valley by freshets from the Keuper and Lias Clays on either side. Upon this grew the trees whose stumps are still embedded in it, and also the water plants and mosses which formed a thick bed of peat. The peat is buried beneath layers of clay which gradually rose above the water and formed the surface of the meadows. In the gravel we find abundant remains of the Mammoth and those Arctic animals usually associated with it, but we have as yet found very few traces of pre-historic man. When he first reached the banks of the Soar, he no doubt found its basin covered, as it was for centuries afterwards, with thick woods. The great changes which have been produced in its appearance since that time have been the result of clearing, drainage, cultivation, and the settlement of a dense population.

Dr. W. Marcet, M.D., F.R.S. (London), considered Mr. Paul had contributed an important page to the geological history of the country, and suggested that the damp clay soil of Leicester might have something to do with the prevalence of infantile diarrhœa and consumption. He congratulated the inhabitants of the town on possessing a supply of good water.

Mr. F. T. Mott (Leicester) disagreed from Mr. Paul as to the probable original height of the Cherwood range. Surely it must in Palæozoic times have been very much more than double its present height to account for the geological phenomena of the district.

Mr. G. J. SYMONS, F.R.S. (London), pointed out that Leicestershire was within measurable distance of the dryest part of England. He welcomed the paper because it dealt with the river basin. When the natural divisions of a country were considered as indicated by the river basins, questions of river pollution would be more easily settled. The multitude of different divisions in this country would be incredible if not true. There were political, legal, ecclesiastical, registration, county, parish, hundreds, poor law, sanitary, urban, rural, water supply, gas supply, and, in fact, almost innumerable divisions, interlaced and overlapping, and more complicated than any Chinese puzzle. The sooner common sense prevailed, and river basins were adopted, the better.

On "*A recent Legal Decision, of importance in connection with Water Supply from Wells*," by W. WHITAKER, B.A., F.G.S., Assoc.Inst.C.E., Assoc. Mem. Soc. Med. Officers of Health.

NEARLY 40 years ago two deep wells (with borings) were made at Brentford, which, passing through Gravel, London Clay, and the Lower London Tertiaries, reached the Chalk at a depth of about 315 feet, and were carried some way into it.

One of these wells is at the Brewery on the southern side of the High Street, now known as the Royal Brewery, and it continued in use till its water became unfit for brewing-purposes, from the cause noted below. The other is 99 yards off, north-eastward, at some printing-works at the back of the houses on the other side of the street. This one was made for a Distillery which has long ceased to exist; the well too has been abandoned, at least for its original purpose of water-supply.

Unfortunately, however, some years ago (between 1874 and 1882) the Distillery well, as we may call it, was turned to a baser use, being made into a cess-pit, by turning it into the drainage of the privy belonging to the printing-works. This misuse has ceased for some three years; but not before a considerable deposit had been formed in the well.

The water of the Brewery well, once of good quality, having been found to have become gradually contaminated, the owner, Mr. M. Ballard, sought to discover the cause, and, the misuse of the Distillery well having come to his ears, he was led to

attribute to that the falling off in quality of his own well-water, the use of which was at once discontinued.

This led to his bringing an action against the owner of the Distillery well, Mr. Tomlinson, for heavy damages, and, although the misuse of that well was then stopped, of course its effects on the water of the Brewery well did not cease, and were not likely to for some time. Having, in the course of the proceedings, been consulted on the Plaintiff's behalf, I may be allowed to call public attention to the importance of the question at issue.

That the two wells get their water from one common source, the Chalk (and perhaps, to some extent, from the overlying sands), is incontestable. When no pumping goes on at either, the water level is the same at both, about 27ft. down in the Brewery well and 37ft. in the other, the site of which is some 10ft. higher.

Practical evidence, however, of the communication between the two was given by the Brewery well being pumped for 48 consecutive hours, whereby its water-level was lowered 78ft. 9in., and that of the Distillery well 14ft. In order, moreover, to make assurance doubly sure the lithium-test was applied at the suggestion of Dr. Frankland, and some of the lithium-chloride put into the Distillery well was found to have been drawn to the Brewery well 48 hours afterwards.

The question, therefore, of communication between the two wells could not be disputed; it was clearly a fact, and the Defendant's case was based on purely legal points, which amounted practically to the statement that any man could do as he liked with his own well, a contention which was successful at the trial before Mr. Justice Pearson, in February, 1884.

The judge ruled that, as it had been decided in the well-known case of Chasemore *v.* Richards, that no one had a right to underground water so far as *quantity* is concerned, or in other words that neither Plaintiff nor Defendant could be restrained from pumping each other's wells dry, or from carrying out works that might take away each other's supply, so also there was no right in *quality;* but that the Plaintiff, whilst having a perfect right to pump as much water as he liked, so as to draw away water from the Defendant's well, must take that water subject to everything that has occurred to it. If he did not pump up the water from his own well he would not get the bad water from the neighbourhood of the Defendant's well. I must own that to my unlegal mind the idea of having a well without pumping water from it was somewhat amusing, and I was inclined to infer that if it had been a case of an overflowing well, from which the water was delivered by the natural force of gravity, instead of by the artificial force of a pump, the decision might have been different, though why I do not see.

In his decision the judge seems to have been somewhat influenced by the possibility that, if the law were otherwise, actions might ensue for like pollutions at great distances, instead of the trifle of 100 yards as in this case, and, in his judgment, he imagines a series of litigants spreading the grounds for such an action over a distance of 60 miles. Though to a lawyer this may seem an inconvenient prospect, I think that sanitarians may be inclined to look on it with no disfavour.

The result of such a judgment amounts of course to saying that no underground water-supply is safe from contamination, even if wilfully brought about. Should your neighbour have a well with a good supply, and you wish to spite him, or to spoil his business, all that is needful would be to put down a bore to the source of supply, and to pour some poison down it! This matter, I believe, was noticed by one of the Plaintiff's counsel. Perhaps, however, in such a case, or in one where sewage containing typhoid or choleraic evacuations was knowingly poured into a well, so as to foul a neighbouring one, the offender might be convicted of manslaughter, in a criminal case, though (under Mr. Justice Pearson's judgment) he would get the best of a merely civil action! This would certainly be a somewhat anomalous state of things, even as regards English law!

So many towns, institutions, and manufactories now get their water-supply by wells in the Chalk, and in other great water-bearing beds, that the result of such a judgment passing unchallenged would have been most serious. It would possibly indeed have been a great check to enterprise in that direction, as water thus got, perhaps at great expense, might at any time be made worse than that got from streams which are more or less contaminated.

The Plaintiff, however, was advised to take the case to the Court of Appeal, and all folk interested in the getting of pure water should thank the Master of the Rolls, and the Lords Justices Cotton and Lindley, for unanimously overruling the judgment of the court below, as they did in February, 1885.

The Master of the Rolls holds that "although nobody has any property in the common reservoir or source [of underground water], yet everybody has a right to appropriate it in its natural state, and no one of those who have a right to appropriate it has a right to contaminate that natural source so as to prevent his neighbour from having the full value of his right of appropriation;" and he goes on to say, in answer to an objection that the water is got by artificial means (pumping), that "however he [the Plaintiff] may appropriate the water from the common

source, he has a right to have that common source uncontaminated by any act of any other person." With regard too, to the question of distance, his judgment is equally satisfactory; for he says that "the question does not depend upon the parties being what is called contiguous neighbours. If it can be shown in fact that the Defendant has . . . fouled . . . . the common source, it signifies not how far the Plaintiff is from him."

Lord Justice Cotton draws attention to the fact that the Defendant was not using the water from his well, but only putting filth down the well, which does not amount to using a natural right, and by so doing, he "interferes with the exercise by the Plaintiff of a natural right incident to the ownership of his own land."

Lord Justice Lindley remarks that the case "really involves the question whether a person who has a well on his own land is at liberty to poison the water which supplies that well and a large district round about it. The defendant says he has such a right. It is a startling proposition to say the least of it." He adds that "the right to foul water is not the same as the right to get it. . . . *Primâ facie* no man has a right to use his own land in such a way as to be a nuisance to his neighbour. . . . If a man chooses to poison his own well, he must take care not to poison waters which other persons have a right to use as much as himself. . . . The right of a man to get water from his well is to get the water as nature supplies it."

As a geologist, much interested in the question of water-supply from underground sources, it was with a feeling of great relief that I heard of the view of this case taken by the Court of Appeal, and I read the full report of the judgments (from which the above quotations have been made) with much pleasure. I am inclined to think, indeed, that Mr. Justice Pearson, albeit he seems to hold strongly to the opinion that this is a free country, may feel relieved rather than grieved at the reversal of his decision. Had it been upheld, there would clearly have been great need of a little law-making.

Although all sanitarians must be glad at the final decision in this case,—for it will not be carried to the House of Lords,—yet it seems unfortunate that the privilege of bringing up so important a matter for settlement should have fallen to individuals instead of to corporations or to companies, on whom the expense would have more fairly fallen. It may be but a poor consolation to both Plaintiff and Defendant, that their names will become famous, like those of Chasemore and Richards, from the case of Ballard *v.* Tomlinson being one that is likely to be quoted for many years, as giving a most important decision in the law of water-supply from wells.

Whilst it was decided, in the earlier case, that every owner has the right to draw underground water to an unlimited extent, the decision now noticed is to the effect that no owner has the right to pollute a source of water-supply common to his own and other wells. Whatever may be the fate of the former decision, it is to be hoped that the latter one will never be altered.

W. Marcet, M.D., F.R.S. (London), thought there was but little to discuss in this paper. The whole question was whether or not a nuisance had been committed. If a nuisance had been committed, the offender was amenable to the law; and he held that just as contamination of water by a neighbour above ground would be ruled as a nuisance, such contamination below ground should be considered in the same light.

Prof. F. S. B. F. de Chaumont, M.D., F.R.S. (Southampton), said it would be interesting to hear from the Town Clerk whether, in his opinion, this decision would enable any person to bring an action against his neighbour for having a porous cesspool which fouls the earth and probably the water.

Captain Douglas Galton, R.E., C.B., F.R.S. (London), observed that at Gravesend the people had long been in the habit of making excavations in the chalk for cesspits. The advantage of the system was said to be that they never needed cleaning out; but after this had been going on for fifty years, it was now discovered that injury was being done to the water supply.

On "*Hygienic Analysis*," *by* Charles E. Cassal, F.I.C.Exam., F.C.S., Public Analyst for Kensington, Senior Demonstrator, Department of Hygiene, University College.

The relation of the public analyst to the public health is as yet but imperfectly understood. People have a vague kind of idea that there are such persons as public analysts in existence, and that the magnitude of the fees to be paid to them for "analysing" is out of all proportion to the value of their work, considering the extreme ease with which they ought to be able to tell at a glance the exact composition of any and everything that may be submitted to them. And it is not the general public only, for numbers even of those who have had some sort of scientific teaching are very much at sea as to what the public analyst can and ought to do; while there are others who, because at one time they have had a three months' more or less imperfect course of teacing in some laboratory, or in a chemist's shop, consider themselves amply qualified to pronounce upon the purity of water or milk, and to give decisive certificates in other equally important matters. Of this, indeed, there are very numerous instances, especially in regard to water, milk, and to the detection of arsenic in wall papers. Waters are sent to the local chemist—even in London—a man generally possessed of the most hazy ideas of analytical chemistry in general, and no ideas whatever on water analysis in particular; or, again, they may be sent to the doctor. In some cases the chemist and the doctor know enough to send the samples on to an analyst of repute, with some pretension to the title of chemist; in some rare instances they know enough by practice and experience to make a fairly satisfactory analysis, and to give a proper report themselves; in others they proceed to "examine" the water, and give a report, when they are totally unqualified in every way to do so. I know of instances in which a water, having been thus examined, a report has been received as follows:—"This water is one of second-rate quality;" and again, "This water may produce typhoid fever"—fee, two guineas. The number of instances in which waters are passed as fit for use on utterly insufficient evidence is very great, and has served largely to bring discredit upon water analysis and water analysts, who in this respect suffer to a great extent for the sins of those who are utterly unfit to deal with the subject. Again, with regard to milk: the lactometer, a most misleading instrument, is used by milkmen to demonstrate the undoctored condition of their commodity, and is believed in by the public. It is used by the wary householder when he imagines that there is a suspicious blueness or want of richness about his milk—an apparent want of richness which not unfrequently occurs when the milkman has not put enough annatto into the sample to give it a slight yellowish tint, and it is used by the amateur analyst as the experiment on which to base his report. With regard to the testing of wall papers and other materials for arsenic, mistakes are extremely common when the work is undertaken by the unqualified, some care and judgment being required, and especially great purity of chemicals: papers perfectly free from arsenic being reported as "highly arsenical," and arsenical papers being franked as perfectly safe.

The fact is, that the delicate processes of analytical chemistry should never be undertaken by those who have not had a full and thorough training, and who cannot show that this has been the case. The title "Public Analyst" is very properly restricted by law to those only who hold a public appointment under the Act, although it is unjustifiably used by others. Analyses should no more be undertaken by the partially trained than cases of disease should be treated by quacks. I have no sympathy whatever with those excellent people who are so anxious that the public at large should test their water, milk, bread, butter, coffee, wine, wall papers, and all the rest for themselves, for while positive results may be valuable, negative ones—which are the more frequent—simply produce a most dangerous state of false security.

Under the provisions of the Sale of Food and Drugs Act, 1875, the public analyst, in his official capacity, is concerned merely with the examination of food and drugs, water analysis and poison cases not being included. On the continent somewhat better provision is made in this respect. For instance, soaps of improper composition, papers, and other articles containing poisonous colouring matters, and patent medicines, are liable to seizure and to condemnation, and their vendors to punishment.

Hygienic Analysis comprises the examination by chemical, microscopical, and other means, of all articles which may have some direct or indirect bearing on health. The analysis of water and sewage, of air, of food, of constructive and decorative materials, of clothing materials, of various soils, and the examination of filters and the so-called—falsely so-called—"disinfectants," forms the principal part of such work, and there can, I think, be no doubt that legislation is urgently required to place as *many* articles as possible under the same conditions as those obtaining in regard to food and drugs; that is, that they shall be made liable to seizure and to examination by the public analyst; and I should like, by the way, to state my conviction that no sanitary inspection of a house or place can be considered satisfactory or complete without an analytical examination of the water supply, of wall papers, of paints, and so on.

It is well known that since the passing of the Public Health Act, and the Sale of Food and Drugs Act, the adulteration of food has largely decreased, in spite of all the legal quibbles which have been used to enable defendants to evade the law—in spite of the fact that the use made of the Act has been so restricted through the wilful apathy of so many interested local authorities—and in spite of the absurdly inadequate punishments inflicted for proved offences. Adulteration has decreased, but it is still enormously extensive, and the adulterators are becoming more scientific every day. The condition of things in a town where the authorities make the Act a dead letter, would, if revealed, be highly interesting to the inhabitants, at any rate to those inhabitants who were sufficiently intelligent. The smallness of the fines which are as a rule inflicted is a direct incentive to adulteration. Where is the use of fining a man who has sold milk adulterated with 20 or 30 per cent. of water such sums as 10s. or £1? But this will no doubt continue to be the case until people generally, and, ultimately magistrates, succeed in comprehending that such a thing as milk adulteration is not merely a mild fraud, but is a direct attack upon the health, and, in the case of young children, even the lives of the community.

As regards the hygienic analysis of air, the knowledge of the normal condition of the air of a town, a large institution, or a factory, is evidently a matter of great importance, and the hygienic analysis of air, when properly carried out, is quite capable of coping with the problem. But it is a decidedly delicate matter, and requires time and trouble to obtain definite and valuable results. The various easy tests proposed, such as the household test for excess of carbonic acid devised by Dr. Angus Smith, and the graduation of the stuffiness of a place by an educated nose, have not in reality a very extended use, nor are they capable of invariably yielding certain and satisfactory results, although in exceptional cases they are no doubt valuable. The analysis of air for sanitary purposes is only really valuable when it is carried out by specially skilled hands, and with proper and complete apparatus, the chief points in the analysis, the determination of the exact quantity of carbonic acid present, the increase of this gas being proportional to the degree of foul organic pollution, and forming the easiest and most certain measure of the latter in the present state of our knowledge; and the microscopic examination of the sediment obtained by passing a large quantity of the air through an apparatus, whereby the suspended matters are caught in a drop of glycerine on a glass slide, or by some such means, are processes which require great care and numerous precautions.

Water analysis for sanitary purposes is a subject upon which there exists a most extraordinary amount of misconception. There are a great number of fallacies current upon it, not merely in the public mind, but even among those who are professionally engaged in the making of analyses. It is one of the sanitarian's most valuable weapons when it is properly carried out, but it is a source of danger when this is not done. Many people are foolish enough to think that when a water has been "analysed" it has thereby received a kind of insurance against subsequent pollution, and there are others who imagine that sanitary scientists are all wrong about water, that the drinking of sewage is rather beneficial than otherwise, and that therefore the sanitary analysis of water, like many other sanitary things, is *de trop*. I am acquainted with a country general practitioner of the old school, who was the happy proprietor of a well, the water of which was grossly polluted by a cesspool placed, as is usually the case, close to the well. That water contained as much as 20 grains of chlorine in the gallon, derived almost entirely from sewage pollution. He was in the habit of making up the mixtures for his patients with this water, and used to say that they thrived on it well. What can you expect from the public when such notions exist among professional men?

It has been of late very frequently remarked by some professional journals that water analysis, as at present practised, is "no use" when the question of infection is under consideration. No greater fallacy exists. Water analyses, when they are complete, are perfectly capable of dealing with all probable cases. Partial analyses are worse than useless; and people who work by rule of thumb, and those who form their opinions upon the determination of any single constituent of a water—as many still unfortunately do—are those who bring discredit upon water analysis, and make such statements as those above quoted possible.

It is chiefly on the authority of a report of some experiments carried out under the auspices of the Local Government Board, and published in the 11th annual report of the medical officer, that such statements are made by those who are evidently incapable of understanding the experiments in question, and especially the tremendous fallacies which underlie them, and the utterly erroneous conclusions drawn from them. It must certainly be admitted that cases might occur where infective matter was present in a water to such a small extent as to be beyond the reach of any analytical process; but I altogether deny that there are any *proved* cases of the kind on record, and I contend that no case whatever can be cited where a water having, on undoubted evidence, produced disease has on a subsequent *thorough* analysis been reported as pure. There is a criticism on the report above referred to in last year's transactions of the Medical Officers of Health Society, by my friend Dr. Whitelegge, the Medical Officer of Health for Nottingham, and myself, and we shall be glad to find these criticisms combated by those who uphold the opposite view. This has not yet been done.

In connection with milk analysis, I should like to point out the desirability of the making of full analyses by competent persons. No analysis can be considered satisfactory unless quantitative determinations of the total solid matter, the fat, the ash, and also a microscopic examination have been made. I have just recently seen in a well-known and most valuable journal a short paragraph on milk adulteration, which commences by saying that "to distinguish between the water of the milk and that added to it by the milkman is a problem hitherto unsolved;" the paragraph then goes on to give an account of a test proposed by a Mr. Uffelmann, which is based on a reaction for nitrates, which will be successful with "two drops of ordinary drinking water." This gentleman considers that if he obtains his reaction it is a proof of adulteration (!); and, to quote again, "that we here have a positive evidence," because nitrates, according to him, are present in some proportion in nearly all waters. I mention this paragraph, bristling as it does with the most palpable absurdities, as a further instance of the ignorance that prevails, and the nonsense that is published on hygienic analysis, in quarters whence one might expect better things.

If the time at my disposal, or the scope of this paper permitted, it would be easy to point out still more fully how direct is the bearing of properly conducted analytical work on the public health. In a recent case where I certified a sample of mustard to be adulterated with 25 per cent. of flour and some turmeric, an inquiry was made as to how much flour I would allow in mustard—apparently with the idea that mustard and flour ought to be sold together, and evidently without any notion that even here there is a danger. It may seem absurd at first sight to some, though surely not to any in this audience, but such things as mustard plaisters are frequently wanted in cases of emergency, and the result is not likely to be satisfactory if, instead of a mustard blister you simply apply a mass of dough. Pepper, again, is an article which has been subjected to the grossest adulteration—especially black pepper. If I find a black pepper to contain much more than 7 per cent. of total mineral matter I advise a prosecution. The defence set up as a rule is that the pepper has been kept in a bag or drawer, and that in course of time the adhering mineral matter—clay and sand—have been shaken down. This, of course, is negligence, and the public must be protected for obvious reasons from buying and eating clay and sand instead of pepper. Although the actual quantity taken is small, it is easy to show that small amounts may play a very great part in the health of the individual. Instances might be multiplied. I would merely just mention two more, viz., those furnished by the so-called "disinfectants" and by the "dyes" used for clothing. The greatest ignorance again prevails about these matters. As regards the former the public are deluded by lying advertisements as to the value of various nostrums for disinfection; and as to the dyes, cheap clothing, and, for the matter of that, dear clothing too, is loaded with dyes that are not *fast*—which evaporate easily by the warmth of the body, and to the deleterious effects of which there are many persons who are peculiarly susceptible.

In the district of Kensington the minimum number of samples to be examined per annum by the Public Analyst, was recently fixed at 500, and the local authority is most anxious to apply the Act as its framers intended that it should be applied. I venture to express the hope that more local authorities throughout the country may, before long, be imbued with some such spirit as this—that they will understand that it is their duty to apply the Acts for the prevention of adulteration to their fullest extent, and, indeed, to demand an extension of legislation to apply to those articles which are at present untouched by the public analyst, in the interests of the communities which they serve and of the public at large.

Dr. W. Marcet, F.R.S. (London), urged the importance, in cases of doubt, of having a thorough analysis of water, including its examination for bacilli, made by a capable analyst, and instanced the experience of the town of Geneva, where such examination and the subsequent steps taken had so far checked the recurrence of epidemics of typhoid fever.

Mr. F. T. Mott (Leicester) said there was no doubt as to the importance of analysis for the detection of food adulteration, but contended that there should be a limit to legislation in this direction. By too much protection of this sort the people might become intellectually pauperized, and neglect altogether to exercise their own common sense. The law should protect the public against any injurious adulteration, and against adulteration which ordinary common sense could not detect; in all other respects they should be left to judge for themselves. Some people liked potatoe flour in bread. Mustard adulterated with flour was not injurious, and anyone could tell whether sugar was adulterated with sand.

Capt. Douglas Galton, C.B., F.R.S. (London), thought very few would agree with the last speaker. What they contended for

was that the public should know whether they were getting the genuine article or an adulterated imitation. He fully agreed with Mr. Cassal as to the uselessness of incomplete water analyses, many of which were misleading and absurd.

Dr. B. A. Whitelegge (Nottingham) pointed out that private individuals presented very few articles for examination by the Public Analyst under the Act, which seemed to be very little known to the general public. Analyses of adulterated foods were almost always made at the instance of the public authorities. It would be very difficult to draw the line, as suggested, between adulterations which were injurious and those which were not. In most cases the penalty was to be regarded as inflicted on account of the fraud, not of any definite injury to the consumer. Since the number of samples taken of any article must necessarily be few, it was clearly the duty of the magistrate to impose substantial penalties where adulteration was proved, in order to act as a deterrent to others. Unfortunately this was not always the case. It would be interesting to watch the Parisian experiment of allowing the public to bring articles to the Municipal Laboratory for analysis.

Mr. G. J. Symons, F.R.S. (London), said there was another Parisian practice he should like to see adopted in this country. In any case where adulteration was detected, the offending trader was not only condemned to the payment of a heavy fine, but was bound to put a placard about a foot and a half square in his shop window, announcing what he had been doing and what punishment had been inflicted.

Alderman Paget (Leicester) said the practice of the Sanitary Committee in Leicester for water analysis was as follows: An analysis was made of the water obtained from the wells sunk outside the town, free from any possible sewage contamination, and therefore presenting the natural qualities of the unpolluted water of the district. This analysis is taken as a standard with which an analysis of the water from a suspected well is compared; and the amount of pollution shown to exist determines whether or not the well should be closed.

Mr. C. E. Cassal (London), in reply, said no analyst was in a position to report on the quality of water until he had made as complete an analysis as possible, together with a careful microscopical examination. In a Sanitary Congress he should have thought it unnecessary to insist upon the desirability of not allowing adulterated articles to be sold. The amount of information a man would obtain by the exercise of "ordinary common sense," would be very small indeed in the examination of food or of anything else. Taking the case of sugar and sand for example, as it had been alluded to—although the sanding of sugar was a thing of the past—it was quite possible that a person might detect the presence of fifty per cent. of sand in sugar by means of his "ordinary common sense," but he would be utterly unable to detect five per cent., without some knowledge of analytical methods. The adulteration of mustard with flour became a very serious thing in the case of a mustard plaister suddenly required, and might involve the balance of life or death. Milk adulterated with water, or deprived of a portion of its fat, was highly injurious to children—and it should be remembered that the water used for adulteration was not always clean—and that in consequence such milk had been the cause of outbreaks of disease over and over again. It was to be deeply regretted that those who were charged with the administration of the law did not seem to understand that milk adulteration was not a mild offence, but was in reality a serious crime, and should be punished with great severity. The fines inflicted were absurdly inadequate. A fine of £50 was not at all too great for putting say 20 per cent. of water in milk, and when a person had been convicted more than once, a term of imprisonment, without the option of a fine, should be inflicted.

Not only was a much greater extension of the Act absolutely required, but it was necessary that local authorities generally should appreciate their duty to those whom they represented better than they did at present: by the appointment of duly qualified analysts, by taking care that a large number of samples should be seized and analyzed, and that prosecutions should be instituted and carried through; for at the present time, except in rare instances, the Act was not properly carried out—being, in fact, in most places, practically a dead letter, and the public were not protected as they should be.

On "*The use of Sodium Aluminate for Softening and Purifying hard and impure Water, Deodorising and precipitating Sewage, waste water from factories, &c., by* F. MAXWELL LYTE, F.C.S., F.I.C.

ACCORDING to Roscoe, the formula for the above salt is Na_2 Al_2 O_4 (atomic weight 165) and although other authorities give different formulæ, that of Roscoe may be assumed to be correct, as this formula also agrees with the percentage composition of the soluble portion of the salt given by Unverdorben and others.

Where in solution, even in distilled water, it has a tendency to lose alumina, and approach to the composition $Na_2\ Al_4\ O_9$. Sodium Aluminate is further decomposed by many neutral salts, acids, and acid salts; forming, in the former case, insoluble aluminates, and in the latter, aluminium hydroxide. As an example of the first may be cited the following:—$Na_2\ Al_2\ O_4 + Ca\ SO_4 = Ca\ Al_2\ O_4 + Na_2\ SO_4$. I have followed Roscoe's notation, though from the reasons above stated, the other formula is perhaps a better practical guide to work by. I find the Sodium Silicate which crude aluminate contains is also of use, being decomposed, and its soda acting like $Na_2\ O$, while the Silica is precipitated with the lime. In this case, not only is the permanent hardness due to the $Ca\ SO_4$ or other earthy salt destroyed, but if the water also contains temporary hardness, the calcium aluminate may be decomposed, with formation of calcium carbonate and aluminium hydroxide, which latter may take up much of the organic matter, if any be present. Water may thus at one and the same time be freed from—

(*a*) Permanent hardness.

(*b*) Temporary hardness.

(*c*) Organic impurity, leaving in solution only Sodium Sulphate in such minute quantities as to be tasteless, harmless to health, and incapable of affecting even the most delicate colours. The time required for the complete precipitation of the aluminate varies in different waters from a few minutes to several hours. In many cases it is therefore advisable to use some kind of mechanical filter or a subsidence machine, such as the "Stanhope" purifier. The decomposition of the insoluble aluminate is slow, and the setting free aluminium hydroxide only takes place gradually unless frequent agitation be applied; where then the water is temporarily hard, or is contaminated with much organic matter, where time is an object or where it is desired to retain unaltered any hardness it may possess, so as not to cause it to become "flat," the former process may be supplemented by the use of sodium aluminate conjoined with aluminium sulphate, as shown by the following equation:—$3\ Na_2\ Al_2\ O_4 + Al_2\ (SO_4)_3\ 18\ H_2O = 3\ Na_2\ SO_4 + 4\ Al_2\ (HO)_6 + 6\ H_2O$. This formula is very applicable to the purification of sewage, waste waters from factories, &c., and it shows considerable economy on any other mode of producing a precipitate of a given amount of alumina. Its advantages consist:—

1. In its economy over any other process for precipitation by the aluminium hydroxide, and

2. In the comparatively harmless nature and small quantity of the salt left in solution.

The usual way of obtaining the hydroxide is by aluminium sulphate and lime, or chalk. But the sulphate contains, even when pure, only 15·44°/$_o$ of alumina (the commercial salt 2 per cent. less), whereas the sodium aluminate contains from 52⅓ to 62½°/$_o$ (the crude aluminate 33 to 40°/$_o$), so that a very much smaller quantity of the latter will suffice to produce a given quantity of the hydroxide. Again, by using the sulphate with a base of any kind (other than aluminate) the quantity of salt left behind will be greatly increased, and if lime or chalk be used, it will give to the water permanent hardness. With regard to the question of cost. Sodium aluminate has never been manufactured in England on a large scale, so that its price is at present abnormally high, although there is reason to believe that it may before long fall considerably.

As it is, water can be freed from 10° of hardness, as well as from organic matter for 1d. to 2d. per 1000 gallons. Practically, and using the crude salt now obtainable, 1 grain per gallon may be said to destroy 1° of hardness.

NOTE.—The 2nd, 3rd, 4th, and 5th paragraphs have been slightly altered, at the Author's request, to put the chemical reactions in harmony with what really takes place, but the final result is the same and continues unchanged.

On "The Danger to Health arising from Burial in Imperishable Coffins," by the Rev. F. LAWRENCE, Vicar of Westow, Hon. Sec. Church of England Funeral Reform Association.

AMONG the evils arising from our ordinary mode of disposing of the dead is that of keeping as long as possible that which ought to be buried as soon as possible. The magnitude of this evil is known only to persons who move among those whose dwelling-place consists of one room. The obvious remedy is the provision of mortuaries attached to every burial-place. But a greater evil exists in improperly burying the body in an imperishable coffin, preventing dissolution, and storing up human remains in every stage and condition of decay. The *Lancet*, in an article headed "A Serious Peril to Health," alludes to certain burial-places as a source of peril, both to those who officiate therein and to those who dwell in the neighbourhood, while Sir Lyon Playfair, the President of the British Association, in speaking of the soils of burial grounds, says, "they are often saturated and supersaturated with animal decomposition," and adds, "I have inspected many churchyards and made reports on their state, which even to re-read makes me shudder." What churchyards have been, cemeteries will be, if this evasive and unnatural method of burial continues to be observed. For bodies to be properly resolved they must be buried in such a way that the earth may have access to them. The burying of bodies in solid coffins is simply heaping up that which destroys the soil, fouls the air, contaminates the water-springs, and spreads the seeds of disease. It is a mistake to suppose that wood decays in the earth. The coffins which were buried more than 200 years ago in the Holborn Burial Ground, were found recently just as they were buried, with their contents in such a condition as to defy description, while the surface had been raised sixteen feet by this mass of arrested and aggravated decomposition. No wonder that this accumulation in our midst of vast masses of human remains, generating poisonous fluids and gases, should have suggested cremation as the better mode of disposing of the dead. But three objections present themselves. Cremation ignores the fact that the earth is the most powerful disinfectant known, and is the natural destination of all creatures that have lived and then died. Cremation necessitates in every case a post-mortem examination, which will be costly, which will often be perfunctory and ineffectual, and which of a certainty will pain the relatives. Cremation facilitates secret poisoning, the evidence of which can be found only in the body. Yet if the dead were properly buried, the evils now most justly complained of would not exist, and the requirements of right feeling and science would be satisfied. The Church's "Order for the Burial of the Dead" provides such. Her use of the words "corpse," "body," "earth to earth," implies burial in the simplest, most speedily perishable coffin in the simple earth. As the *Lancet* put it, in the article already referred to, "the coffin should be constructed, not with a view to its endurance, but to its perishability." This is indeed a better, because more natural, form of cremation, called by Liebig, *Eremacausis*, slow cremation, the earth being in this case the crematory. The body is buried in its own grave, in well-drained, dry, and porous soil, and there undergoes, not mere decay, but a process of transformation. The earth, as earth, does not affect the body, but acts as the porous medium between it and the air above. Through this superincumbent earth the air descends and resolves the body into new and harmless products, carbonic acid and ammonia, which pass upwards in air; and this process continues for three or four years, until at last the body has, in a lower and more immediate way, literally risen again and become the source of new life, leaving behind it nothing but inorganic matter, and in a few years after the burial the same earth is ready to perform the same beneficent action again. The well-defined laws of nature have been observed, and sanitary evils avoided.

Dr. W. Marcet, F.R.S. (London), said that earth was no doubt a very efficient disinfectant. But they must not forget Mr. Darwin's famous paper on the influence of worms bringing to the surface of the earth organic matter undergoing decomposition at various depths.

Mr. H. P. Boulnois, M.Inst.C.E. (Portsmouth), maintained that pollution of the earth must take place wherever dead bodies were placed beneath the surface. The gases emanating therefrom passed into the air, whether the decomposition was a rapid or a slow process. There were many cases in which drainage from burial grounds polluted the streams, and he had heard of a case in which cattle were poisoned in consequence. From a sentimental point of view, he had a great horror of the idea of a person slowly decomposing in the earth. When the spirit had left the body, all that was dear to surviving friends was gone, and he considered it would be far better to at once place the corpse in fire, the most purifying agent known. How long a body would remain in a burial ground was nowadays uncertain; Land was wanted for a railroad, for a new road, or for an improvement of some kind, and forthwith the burial ground was destroyed, and the graves desecrated.

Mr. F. T. Mott (Leicester) admitted that the present system of burial was exceedingly defective. The question was how to improve upon it without outraging the feelings of the living, and without creating any new form of nuisance. Theoretically, there was much to be said for cremation, but it would take many years before the majority could be persuaded to allow beloved forms to be cast into the fire and burnt up. Burial in perishable coffins in porous and well-drained soils, with no fresh interment to take place in the same grave until after the expiration of ten years, would be a great improvement. He should like to ask whether Mr. Lawrence proposed to allow such an interval to elapse, and also whether under his system the bones would disappear as well as the softer parts of the human frame.

Mr. J. B. Everard (Leicester) said the decomposition going on in

St. Pancras Churchyard, which he noticed while engaged upon some operations there in connection with the Midland Railway extension to London, some years ago, fully convinced him that something must be done to improve the present system of burial. He thought that England was not yet prepared for cremation, for reasons which would commend themselves alike to medical men and engineers. Mr. Lawrence's suggestion to some extent met the difficulty.

Captain Douglas Galton, R.E., C.B., D.C.L., F.R.S. (London), said it was a curious fact that in the Franco-German war, in disinfecting some of the battle fields, some very interesting observations were made as to the effect of different soils in assisting the decomposition of bodies. It was found that in chalk bodies disappeared altogether after a year's interment, while in clay they were almost entirely preserved. A large part of England was clay, and there was no doubt, even adopting the plan suggested by Mr. Lawrence, bodies would be preserved for a very long time. The question of cremation in connection with those who died in metropolitan small-pox hospitals, would no doubt come up for consideration on some future occasion. There was one point of the very highest importance not touched upon in the paper, and that was the very grave objection there was to allowing the bodies of the dead to remain amongst the living for so many days, as was the custom in this country. Numerous mortuaries ought to be provided in all towns and villages, and all corpses should be removed into them soon after death, unless the bodies were sealed up in lead coffins.

Alderman Kempson (Leicester) remarked that an alteration in the law would be necessary for the enforcement of the removal of corpses to mortuaries. When the Leicester cemetery was first opened a mortuary was provided, but it was so little used that in a few years it was pulled down. Agreeing to the necessity for an improved system of interment, he thought the country was not yet prepared for cremation.

Mr. G. J. Symons, F.R.S. (London), pointed out that the condition which had been demanded, viz., that a cemetery should be well-drained, was a serious danger to the water supply. As a supporter of cremation, he had no doubt that if people were only acquainted with what really went on underground in the horrible work of decomposition, they would all become supporters of cremation too. One original argument against cremation was, that it would render impossible the detection of poison in the body in cases where foul play was suspected. The Cremation Society had provided against that, and in cases of doubt held itself free to decline to carry out the process. They already required medical certificates as to the cause of death from more than one medical man.

Dr. B. A. Whitelegge (Nottingham) did not attach very great importance to the preservation of the body for a few weeks or months for the sake of possible medico-legal investigations after interment, but still he did not think that absolute security against foul play could be obtained by means of medical certificates, as suggested. Cases of poisoning, for instance, were of rare occurrence, and as the symptoms often closely resembled those of diseases which occurred daily, it was more than probable that some of the former would escape detection, however vigilant a watch were kept. Burial in solid wooden or leaden coffins certainly needed reform, for the present system was bad, and the proposal to leave burial grounds undrained would only make matters worse. While Mr. Lawrence's plan was a great improvement, and deserved to be warmly supported too much was claimed for it in one respect, viz.: as regards the asserted "disinfection" by earth. In point of fact, earth was a very poor disinfectant indeed, though an excellent deodorizer. It was now generally recognised that, so far from destroying bacteria and their products (which was the true meaning of disinfection), the earth and the subsoil water often played a most important part in the spread of certain diseases by such means. It was said that it was the natural thing to restore the body to the earth, and to utilise again the elements of which it was composed, but the present system of burial scarcely attempted to do either. The question of providing mortuaries was of great importance. They had been established to some extent in Nottingham, but the poor showed great prejudice against them.

The Rev. F. Lawrence (York) in the course of his reply, said that decomposition of human remains would depend very much on the nature of the soil in which they were interred. Legislation should be sought in three particulars. 1st. To limit the period during which a body should remain unburied. 2nd. To render it illegal to place between the body and the earth anything that should retard its dissolution. 3rd. To compel the directors of cemeteries to supply each body with sufficient earth to ensure its speedy dissolution. He did not agree that earth was not a good disinfectant.

Dr. W. Marcet, F.R.S. (London), remarked that the earth successfully absorbed noxious gases, as for example in the case of earth-closets. At the same time there could be no doubt whatever that the body did undergo absolute putrefaction after burial.

THE ESSENTIALS OF LOCAL GOVERNMENT REFORM.

LECTURE TO THE CONGRESS.

By Ernest Hart.

Chairman of the National Health Society.

NEED AND IMPORTANCE OF REFORM.

The question of Local Government Reform is now by universal consent looked upon as one of the very first matters to which the new Legislature that we are on the eve of electing will have to bend its energies. To read the comments which are made upon the subject by public men and in the press, one might think that it was a matter that had only just come within the range of "practical politics," and was now for the first time ripe for reform. We have so many things to occupy our attention now-a-days that we are apt to forget the legislative aspirations and struggles of the past. I take leave, therefore, by way of introduction, to remind you that this is no new subject on which I hope to engage your attention to-night. At least seventeen years ago, within my personal political experience, local government was quite as burning a question as it appears likely to become now; and we ardent sanitary reformers of those days were in great hopes of the accomplishment of a thorough and satisfactory settlement of the very difficulties under which the nation is now, as it was then, ignorantly suffering with a kind of fatalistic idea that they are insurmountable. The chaos of local government was felt then, as it is now, to be a primary obstruction to efficient sanitary administration. There are these differences, however, between the state

Local Government Reform not a new cry.