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LECTURES ON PUBLIC HYGIENE AND MEDICAL POLICE.

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LECTURE V.

There are various employments, in which great numbers of the inhabitants, especially of the younger class, in all manufacturing countries, are engaged; and which, either from the confinement in closed buildings, or other restricted places, or from exposure to the vapours of substances under manufacture, or from the manipulation of them, prove more or less detrimental to health and vigour, and many of them productive of disease, and tending to shorten life. It, therefore, often falls to the duty of the medical practitioner, either from a public requisition, or from municipal or private desire of investigation, to enquire into the hygienic effects of such various employments upon the health and longevity of those exposed to their influence, in order that he may deliver an opinion how far, and in what manner, these influences extend and operate, and be enabled to point out how any ascertained evils or injurious tendencies may be corrected or removed.

On some of these subjects many crude and gratuitous opinions have been delivered, without sufficient information and data having been previously acquired; and no little controversy has, from time to time, been exhibited, not much to the credit of that calm and philosophic spirit which at all times should characterize the investigations and evidence of professional men, when applied to, as men of science, close research, and of benevolent yet independent minds.

If we were to enumerate every profession and trade that has more or less influence on health and longevity, we might begin with those which, in common opinion, might seem rather to promote the one and to prolong the other, than to be anywise injurious. *Affluent idleness* may seem to be above the reach of any special evil of this description; but when we consider the long catalogue of such disorders as hypochondriasis, tedium vitæ, dyspepsia, and gout, to which such a life is subject, we may

well place the rich and the idle in some analogous category with the artisan and the operative in a hygienic respect. But as the characteristic ailments of this privileged class are never likely to become an object of medical inquiry and police, we shall pass them over. We may also say the same of the diseases and infirmities to which *literary men, clergymen, lawyers, schoolmasters, and clerks*, are in every speciality liable; and we shall not even touch upon what ailments our *own profession* are most addicted to, though, if we may judge from reports and complaints, poverty and hope deferred would seem the more general and endemic maladies. The diseases of *merchants, master manufacturers, and shopkeepers*, depend more upon the *morale* of the individuals, than upon any thing specially belonging to their occupations. It is not so, however, with the *shopman*: he leads a very different life; early and late at the shop, and in many instances his hours of rest are abridged by the duties of his business, which afford him no time to take exercise in the open air. This is peculiarly hard on young persons from the country, who, from their close confinement, and being immersed in the smoky atmosphere of a town, and in narrow streets, often become early victims to such insalubrious changes.

The diseases to which *sailors and soldiers* are more particularly liable we defer to notice, from their belonging more to the public service than to medical police; and it would be carrying our hygienic review perhaps too far, for us to point out any feasible insalubrity in the occupation of the *agricultural labourer*. The same may be remarked of *carters, postillions, and coachmen*. *Quarrymen and stonemasons* are, however, liable to serious unhealthiness, from the minute dust, which they create, entering the air passages during respiration. This often gives rise to a species of phthisis, and such persons are generally not long lived. Those who work under sheds are more liable to be affected than those who work in the open air. *Marble-cutters*, for the same reason, are unhealthy, and even the employment of a sculptor cannot be held a good one for a person of delicate lungs. *Knife and needle-grinders* are in a similar but more severe predicament. They are subject to what is called the *grinder's rot*, which is an incur-

able consumption, and carries off many of these artisans after a few years at the business. Currents of air and interposed plates of glass have been used to remedy the evil. Screens of magnets have also been employed to arrest the steel and iron particles, which they very effectually do, when paid attention to by the workmen; but they do not in any measure abate the small dust from the grindstone, which is almost as injurious.

Besides needle, edge-tool, and gun-barrel grinders, iron and brass filers, being subject to frequent and many diseases, arising from the metallic dust and particles which are carried into the lungs by the workmen employed in these occupations, many other classes of workmen become diseased in their respiratory organs, and are short lived, from inspiring the fine molecules or dust to which they are exposed, such as sawyers, millers, starch-makers, flax-dressers, weavers, wool-carders, feather-dressers, horn and pearl makers. All of these are universally short lived, and the lesion to their lungs consists in the mechanical irritation to which they are subjected, and not to any poisonous quantity in the particles inhaled. It is not so with dyers and printers, whose hands are exposed to the manipulation of many substances, both metallic and vegetable, which are either of a poisonous nature, or are highly irritant to the animal body. Besides the fumes and sudden changes of temperature to which they are exposed, their trades are otherwise injurious to health. It may be thought that bleachers, from the great changes of temperature to which they are subjected at their work, would be very liable to disease, but I have observed they keep particularly exempt from all complaints, except rheumatism, and they may be considered a very healthy class. I took the trouble a few years ago of measuring the relative height, and girth round the chest, of 100 bleachers, 100 cotton-spinners, and 100 men, rank and file of the 85th regiment, in order to see what might be the relative differences between these very separate orders of men, as to their exposure to the air and their employments.

I have here noted these measurements, along with the average ages:—

100 cotton spinners: average age 26.71 years; average height 5 ft. 4.64 inch.; average measure round the chest 32.67 inches.

100 bleachers or crofters: average age 32.12 years; average height 5 ft. 6.75 inch.; average measure round the chest, 34.24 inches.

100 of 85th Light Infantry: average age 32.67 years; average height 5 ft. 7.87 inch.; average measure round the chest, 34.8 inches.

None of the spinners were above 45 years of age, while seven bleachers were from 50 to 63.

Besides those diseases resulting from the inhalation of particles of dust, that serve to act only as mechanical irritants to the respiratory organs, there is another large class of disorders which are occasioned by the poisonous or sedative nature of

the molecules inhaled, and from which the workers in mercury, lead, brass, copper, and arsenic, frequently suffer. As plating and gilding have been almost always effected by the amalgams of gold and silver with mercury, the fine particles of this latter metal are constantly liable to be absorbed by the hands of the workmen, or inhaled, in the state of vapour, when the metals are exposed to heat to drive it from the amalgam. Besides many diseases to which such workmen are liable having the character of cachexia, they are frequently affected by a special palsy of the arms, which are seized with convulsive snatches, and at length with habitual tremor. This paralytic tremor often eventually creeps over the whole body, and convulsions and death follow. Several means have been used as a preventive, the chief of which has been frequent ablution, but it is hoped that the new process of electrotypes will in time save the workmen from much of the dangerous fumes to which they have been exposed in these manipulations.

The large class of people who are employed either in the mining of lead, its smelting, manufacture of its oxides, or in the use of the metal in its various forms, as plumbers and glaziers, painters in oil and water colours, typefounders, and colour-grinders, are much subject to that species of colic, called *colica pictorum*, and also to a particular kind of palsy, affecting the forearm and wrist. In the manufacture of white and red lead, which is carried on to a large extent in some establishments, employing a great many workpeople, I have found, what is interesting, that women are less affected than men with the deleterious nature of the metal or its oxides; and I am led to attribute this superior exemption to the female sex perspiring more freely, so that metallic particles are more effectually thrown off the body. Ablution of the hands and exposed parts of the body has been a very good preventive of the peculiar ailments attending this employment; and those workmen who practice this regularly, have been long exempt from any disturbance of the system. Light acidulous beer or lemonade, slightly acidulated with sulphuric acid, and drunk occasionally through the day, has been found in some few establishments to diminish much the number of affected persons. As this acid, the sulphuric, acts by forming an insoluble salt with the oxide, and so becoming not easy of or fit for absorption, and is of itself not deleterious, it is very philosophical to think that its more general use, along with daily ablution at least, will be found a good preventive of these disabling and often fatal complaints.

It may be, as it has been, the case, that we may be called upon, as a matter of medical police, or where there has been a presumption of accidental poisoning, to investigate and give our opinion, whether water for drinking or for culinary purposes be contaminated with lead, or with any of its salts

or oxides. Health has been ascertained to be frequently injured from such sources, so that in many cases it becomes an object of much importance to detect and verify the presence of this metal or its compounds, in any waters that are used for the above purposes. It has been a matter of much discussion, whether water can hold in solution so much of any of the compounds of lead as to prove at all deleterious; while much difference has existed as to the form in which the metal has been, where a poisonous effect has been clearly ascertained.

From many experiments and observations made by Drs. Thomson, Lambe of Warwick, Christison, and also by Capt. Yorke, it has been found that pure distilled water has the greatest solvent power on the metal, and next to distilled water, rain and snow water have the most power. The state into which the metal is converted is an hydrated oxide, combined less or more with carbonic acid. The danger of contamination is greatest from new lead, on which these waters act with their greatest corrosive power, but when the metal becomes coated over with a film of the carbonate, which is nearly insoluble, the metal underneath is protected, and so the waters may become free from any plumbeous impregnation. Therefore rain water collected from newly laid leaden roofs, ridges, or gutters of houses in the country, is the most liable to be impregnated, and I have known two instances in this county where serious derangement of the health of two families, and death in one of them, occurred from this cause. The lead that is kept covered with water, as under the water line in cisterns, is not affected, it is only where the air and the water act together; thus in examining a leaden cistern we find, just at and above the level of the water, a white incrustation, which is the carbonate of lead, while below this level the metal remains clean and uncorroded. The remedy and prevention of this poisonous solution are easy and simple, for it is found that a very small addition of some of the salts and acids, as the phosphate or acetate of soda, or even of common salt or nitre, or of the sulphuric or muriatic acid, keeps the carbonate from forming, or else decomposes it, and an insoluble salt of lead is formed, which sinks to the bottom. As most of our river and well-waters contain small portions of earthy salts, they are kept by them sufficiently pure in cisterns, or when running through leaden pipes; and as the atmosphere of our large towns is much contaminated with adventitious acids and salts, as sulphurous acid and ammonia, the rain-water collected in our cisterns is preserved so far innocuous.

A *Conseil de Salubrité* at Paris, lately made an enquiry into how far the leaden cisterns used by bakers was apt to injure the bread; but they seemed to consider that the only contamination that could arise was from the carbonate of lead, and

this they held to be quite insoluble, always falling to the bottom. They decreed, therefore, that the bakers might be permitted the use of leaden reservoirs, if they put a cock three inches from the bottom of the reservoir, in order that if any of the insoluble carbonate be formed, it might be deposited in the water below the cock, and that the reservoir be cleansed out once a month. For greater security, the bakers were required to cover the lead which lines these reservoirs with a coat of wax, to prevent the formation of any carbonate in any condition of the contained water. A more effectual preservative is found by lining the cisterns of lead with tin. Lead may be detected in water if present in any minute portion, by first carefully filtering it, then acidulating it with a drop or two of nitric acid, and evaporating to dryness. From the residue any excess of nitric acid is expelled by heat, before it is dissolved in distilled water, to which sulphuretted hydrogen, hydriodate of potass, or the chromate of the same, may be applied to discover the lead. In addition to what we have generally stated as to the preventive power of the neutral salts, it is found that 1-30,000th part of phosphate of soda, or 1-4000th of sulphate of lime, 1-2000th of muriate of soda, 1-7000th of sulphuric acid, and 1-3000th of muriatic acid, will preserve water free from all but the most harmless impregnation of lead.

As lead, or its oxides, is found frequently in various articles of food and drink, and to have an injurious effect upon health, we are also called to investigate these matters. The principal articles in which the metal is found, are wines—especially the aerated, ciders, some fruit preserves, and food that has been prepared in glazed dishes, but as these matters belong more to the toxicological part of our course, we will not enter upon their consideration at present. We also defer noticing the manufactures of soda, muriatic acid, and sulphuric acid from pyrites.

There is no employment that has excited so much public attention and enquiry, and has been so much discussed, as to its effects on the health, morals and longevity of those employed in it, as the manufacture of cotton, especially as regards the spinning process. If we were to believe some men, even of eminence in our profession, the employment is a species of wilful and heartless infanticide—a perfect altar to Moloch; and if we could credit others, equally respectable, but apparently better acquainted with the process, it is not only a healthy occupation for childhood and adults, but also a preventive, if not a means of curing consumption and cachexy. Like many questions of a similar kind, the assertions are derived either from separate data, or from a foregone conclusion founded on the abstract views of physiology applied to unknown conditions. My own observation has shown me that while some establishments situated in towns have an insalubrious effect upon the operatives, and

especially upon the children, arising also from their modes of living and their habitations, others again, situated in the country, have exhibited quite a salubrious and beneficial effect upon the health, morals, and comfort of those employed. The object of the Factory Act has been to improve the hygiene in the worse-conducted and badly-located establishments; and though its provisions have been thought by some to be very stringent, and to interfere too much between the employer and the employed, yet upon the whole, it may be allowed to have improved the physical health of the operatives.

To show how difficult it is to come to a just and satisfactory conclusion, even when the subject is investigated in the most public manner, and by the most respectable and able private observers, we may remark that in Mr. Sadler's parliamentary committee, there was an undoubted perversion of facts pervading the whole of its enquiries, with a subtle commitment of medical men to the side obviously espoused by the leading members of that committee. On the other hand an eminent chemical philosopher has excessively eulogized labour in cotton mills, as contrasted with rural pursuits. The faults of exaggeration and partiality in the selection of illustrative cases, lie seriously at the doors of such reporters; and more recently Dr. Taylor has betrayed somewhat too much of the same bias in his praises of cotton mills and their wealthy owners.

That scrofulous affections and phthisis prevail much in all manufacturing communities, especially in large towns, is a matter of acknowledged occurrence and observation; but then these complaints are found to prevail in all densely inhabited towns, whether there are any cotton manufactories in them or not, and this especially among the poor living in narrow streets, in filthy, dark and ill-ventilated cellars and lodgings, seldom or never perhaps reached by the sun's rays. In proof of this insalubrity not being attached *par excellence* to manufacturing towns, I may instance Liverpool, which has a higher rate of mortality and a presumable greater prevalence of disease than Manchester, principally owing to the former, a non-manufacturing town, having a vastly greater number of people living in dirty cellars.

As to the comparative mortality in the two towns, of all ages under 15, to show how children and infants are affected, the ratio of deaths in Liverpool is to the whole deaths, as 60.75 per cent., while that of Manchester is only about a half per cent. higher, being 61.27 per cent. Mr. Noble, in a paper read before the British Association, in this town, showed that the deaths from consumption in the factory district of Manchester were actually fewer in proportion to the deaths from all causes, than in the agricultural county of Essex, being as 4 to 21 in Essex, and 3 only to 19 in Manchester; and a similar favourable ratio for

Manchester was deduced, when compared with the rural parts of the country in general. Something of this favourable nature is reported by Dr. Mauthner, of the cotton-works, in Lower Austria, in which about 10,000 hands are employed, within a circle of a few miles round Vienna. He says, from the registers that have been duly kept by the clergymen for forty years, that the number of deaths among the manufacturing people, is proportionably less than among the agricultural labourers; that, as among other classes, the deaths are most numerous of children under two years, and that there are a great many who die between 60 and 70. In these foreign establishments the hours of labour are longer than in this country, being generally fifteen hours, including time for meals, but the people are well lodged, and they are temperate in their habits. To balance this view in some degree, Dr. Mauthner says that the race of men employed in those establishments is much less robust than that of the peasantry in the neighbouring villages, and that scrofulous consumption is not uncommon, while inflammatory diseases are rare. Rheumatic affections are the only peculiar diseases incident to the employment.

M. Villermé, a great medical statistician, says of the French factories,—“See these operatives, and you will soon be convinced that these things never inconvenience them. Singular mistakes have arisen in attributing to working in factories, diseases induced by protracted labour, want of rest, insufficiency of food and its bad quality, habits of improvidence, drunkenness, and to say all in one word, wages below the actual wants of the recipients.” We are, moreover, confident in our own conviction, that many diseases that have been attributed peculiarly to manufactures, are not specially to be found among the population dependent upon them; and that the evils both of a physical and moral character affecting the working classes, are more to be assigned to their domestic and personal habits and relations, than to their industrial ones. In further corroboration of this opinion, I had occasion to visit the workhouse at Liverpool lately, and I there witnessed in the children's wards such a number of declared scrofulous affections and sores to which there is nothing similar to be compared, no, not to a tithe, in the Union Workhouse in this town, which contains nearly as many inmates.

That the race of adults in factories is physically deteriorated, there can be no doubt; and if it were not for fresh immigration from the rural districts, they would be more so. From the Army Report, it is found that a corps levied from Wales and the northern counties of England, will last longer than one recruited from the towns of Birmingham, Manchester, or the metropolis; and out of 613 men enlisted, almost wholly from the manufacturing districts, only 231 were approved for service. Manufactures undoubtedly deteriorate the race of men.

How far the physical development of the male operatives would have been kept up and promoted under this species of industrial employment, if no females, at any age, had been allowed to enter a factory as a daily operative, it is not easy to predicate; at any rate, from observation and experience, it may safely be inferred that the moral and domestic condition of both sexes would have been greatly better than at present, and wages would have maintained a higher level, and in this exclusion of females lies the radical reform of this system. Much however has been done to ameliorate the system, for the ten-hours labour has been all but enacted by Act of Parliament, and none are allowed to enter the mills under nine years of age. Not many years back children were liable to be worked fifteen hours a-day, while Dr. Baillie gave his opinion that children might be admitted to work in factories at seven years of age,—an opinion which no medical man would now venture to deliver.

In the woollen factories it appears that the batting of wool occasions much less dust than that of cotton, and that little even of inconvenience is felt from it. The spinning of wool also requires only a moderate temperature, whereas that of cotton requires a very high one. In the silk manufactory it is considered that the early processes, such as drawing the silk from the cocoons, are alone decidedly unhealthy, and any results that take place are those on the general health, rather than special affections arising from the employment.

We come now to notice the hygienic state of another very numerous and important class of people employed in very different situations, and in quite a different species of labour from those which we have yet considered, viz., the condition of those employed in mines, and especially in coal mines. The nature of this employment, especially as it affects the health, morals, and development of children and females, has lately attracted much of the sympathy and benevolent attention of the public, and from the investigation of a parliamentary committee, an Act has been passed to counteract what has been considered injurious yet avoidable in this species of labour, and especially in excluding females entirely from working underground. Like all subjects hastily taken up in the spirit of philanthropy, there is reason to think there has been not a little exaggeration in the published reports of the evils, both moral and physical, that have been alleged to accompany and follow the employment in mines, and in several instances the pictures of slavery and vice have been grossly caricatured. It is with this, as with the cotton factories, the evils depend more on the customs and mode of labour in separate districts and under different owners, than upon any necessary accompaniment or result of the kind of labour itself. For while in some districts the lowest state of ignorance, grossness of morals, and severity

of labour upon women and children prevail, in others, as in some of the mining localities in the west of Scotland, a high state of morals among the operatives exists, and they are as well educated and as attentive to their religious duties, as any portion of the agricultural community around, and even where females worked in the mines. The South Shields committee, in their late valuable report, say, that no women nor girls are employed in the north of England mining districts, and they further say, it is surprising that so little physical injury should be the result of the labour among male children. They are decidedly of opinion that no restriction should be placed on the admission of boys to the mines beyond 11 or 12 at the latest. Boys must be early brought up to the work, else they will never, when further grown, take to a mine—a circumstance which has been much overlooked in many fine plans propounded on this subject.

There are no special diseases to which coal-miners are subject, save those which are the obvious result of exposure to wet and damp, along with frequent changes of atmospheric temperature, and the inhalation of coal dust, and these causes declare themselves in recurrent attacks of rheumatism and bronchitis. On the whole, however, they may be termed a healthy class of people, and many of them are very robust; and their spasmodic complaints result more from their intemperance than from any special causes attending their employment. The principal invasions of their health, physical ability, and longevity, arise from the accidents to which they are so liable, and to which so many are the fatal victims. Contusions, wounds, fractures, and dislocations, are familiar accidents among them, occasioned by misadventures in the shafts, falling of the roof of the mines, and the minor effects of explosions of either gunpowder or of the fire-damp. Though the recent Act of Parliament has wisely upon the whole provided for the exclusion of children and females from the sphere of these terrible accidents, yet it has not ventured to provide a preventive of the fatal effects, so often resulting from the devastation of that demon of the bowels of the earth, the fire-damp, nor offered a premium to any that will effectually conquer or disarm its power. We think this would be a most benevolent devotion of a little money, and a challenge to the sublimest aspiration of fame, when we consider, that, from correct statistical returns, during twenty years previous to the adoption of safety lamps, when only steel mills were in use, 679 lives were lost from explosions in the mines in this country, while from 1820, or the twenty succeeding years, when the lamps were in general use, 744 lives have perished from the same cause, leaving a balance against the lamps of 65 lives. It is true there has been an increasing business done each succeeding year, but the chief cause of this fatal disparity, appears to be, the greater inattention to ventilation, and too much confidence in

the lamps, which are, at least, but imperfect safeguards, when the gas gets much accumulated, and the lamps become hot from internal combustion and explosions. The wire in the best of the Davy lamps soon becomes red hot, and the least wind or movement of the lamp, throws the internal flame on to the gauze, and the dangerous atmosphere without is ignited; or else others, as Dr. Clanny's are apt to go out, when the fire-damp is very rife, though his, or Museler's, of Belgium, is thought to be much better than Davy's.

The nature and habitudes of the gases in coal mines are exceedingly interesting, and though they have been investigated by able chemists, there is much to be yet ascertained, especially as to the proportions in which they act as inflammable and explosive mixtures. They are found to consist of light or the proto-carburetted hydrogen, the olefiant or the bicarburetted, and sulphuretted hydrogen, which are all three inflammable. We have also those gases which constitute the choke and after-damps, the carbonic acid and the nitrogen gases. The *proto-carburetted hydrogen*, which is very light, having only a specific gravity of 0.5382, composes the greatest portion of the fire damp, but it requires for explosion, according to Davy, 7 to 25 per cent. of it to be mixed with atmospheric air. If it is in greater proportion than 25 per cent. the mixture will not explode, owing to the want of a due proportion of oxygen, and if less than 7 per cent. it will be too much diluted for quick explosion. *Olefiant gas*, which is also called the heavy carburetted hydrogen, because it has a gravity of 0.9722, exists in many mines beyond what is supposed. It explodes at a lower temperature than the other; iron heated red hot will ignite it, and thus the lighter gas may be fired. Professor Bischoff found the fire-damp in the coal mines of Belgium to consist in 10,000 parts of light carburetted hydrogen 7910, of olefiant gas 1611, and of other gases 479 parts, and this may very probably be a sample of the fire-damp in several of our mines. *Sulphuretted hydrogen* is very heavy, being 1.1805, and is extricated from the decomposition of iron pyrites, which ordinarily contains 45 to 50 per cent. of sulphur. It causes instant death by inhalation, and ignites at the least visible heat of iron, therefore a red hot lamp will explode it.

Carbonic acid gas is more or less generated in all mines, and frequently accumulates in the workings or bays of coal mines, to a dangerous pitch, so as to extinguish lamps and candles; but even before it reaches this intensity it is dangerous, and in time will be fatal to animal life. Professor Graham even says, that 7 per cent. of carbonic acid in common air would be powerfully narcotic, and soon kill, from repeated respiration. Being a heavy gas, of specific gravity, 1.5277, it is found always at the bottom and lowest parts of the shaft and workings, and is termed the choke-damp by

miners. Its first effect, from an inhalation of the pure gas, is an immediate stricture or irritative closure of the glottis, and the person dies asphyxiated; but where the gas is diluted with common air, death slowly takes place from the narcotism induced by the accumulated carbonization of the blood.

To illustrate the effects of these inflammable and other gases, before and after explosion, we shall suppose a certain dangerous atmosphere to consist of one volume of light carburetted hydrogen and ten volumes of common air, which forms one of the most explosive mixtures. This mixture may be respirable for a while, but its dangerous nature may be perceived by the safety lamps, which will be getting hot by the confined internal explosions, which, however, the miners may not strictly regard. Soon, however, an explosion takes place, either from exposing an open candle, opening the lamp, or from its getting red hot, or even from its being carried quickly through the fatal mixture, so that the internal flame is thrown on the hot wire-gauze, by which the exterior mass is ignited.

The explosion having taken place, what is the result in a chemical view to account for the death of the poor victims, on the fact that they have been asphyxiated by what is called the *after-damp*? Now, as we had one volume of the carburetted hydrogen, which is composed of two volumes of hydrogen and one volume of carbon vapour, making three volumes when the gas is decomposed, and we have ten volumes of air, it is easy to see what will be the result if the explosion has been complete. The two volumes of hydrogen will unite with one of the volumes of oxygen in the air to form aqueous vapour, and one volume of carbon vapour will unite with the other volume of oxygen to form one volume of carbonic acid, while the nitrogen—eight volumes will be set free—the whole making eleven volumes the same as at first, but in the meantime suffering a great expansion from the heat of explosion, and the decomposition of carburetted hydrogen. Now the nitrogen will be found filling the upper and middle regions of this residual atmosphere, while the carbonic acid will be at the bottom, and may extend to about six inches from the floor of the passages. Hence the nitrogen may make a man insensible till he falls into the heavy gas, where he is soon asphyxiated. The nitrogen is merely *negative* in its effects; the carbonic acid is, however, positively poisonous, and will kill even by immersion, with the mouth protected. On inspecting these victims after they are found, many of the marks are those of asphyxiation, but there are also signs of great violence on the bodies from concussion and contusion.

Professor Christison thinks some other injury than simple asphyxia takes place in the death under these circumstances, as the bodies very soon putrify, in some analogous manner, as from electricity.

Before we finish this subject, it may not be irrelevant shortly to take notice of a law in pneumatic chemistry which has been alleged to prevail among all the gases, and tending to modify their interdependency of action. This law is called the law or property of *diffusion*, whereby gasses of whatever different specific gravities, have the property of diffusing themselves among each other reciprocally, atom to atom, or two or more atoms of one species to one of another, and that even though an animal porous membrane be interposed. This property, so beautifully exemplified in the laboratory and in some of the operations of atmospheric phenomena, would have been of essential importance among the different noxious gases that are generated in mines; but unfortunately it does not seem to hold good in such subterranean laboratories. Whether this exception is owing to the want of the solar light, of a sufficiency of medium, or from want of a due intermixture from currents of air, it is not easy to ascertain; but carburetted hydrogen and carbonic acid gases are always found separate, according to their specific gravities.

Professor Graham asserts that the light gases diffuse themselves most rapidly; thus hydrogen escapes from an aperture five times quicker than carbonic acid gas, which is twenty-two times heavier. In the case of an intimate mixture of the two gases, the most diffusive gas separates from the other and leaves the receiver in the greatest proportion. Mr. Taylor, the eminent scientific miner, says, no practical value can be deduced from the law of diffusion, as applied to mines. "At the highest point," he says, "I found a very explosive mixture, and no trace of carbonic acid could be detected by lime-water. At the lowest point, the mixture was not explosive, and there was a good deal of carbonic acid. We cannot therefore, it appears, calculate upon any results of this law in mines; it is of little or no use."

In the *after-damp* also, the law of diffusion does not hold good, for the different products of nitrogen and carbonic acid gas that remain in the passages, are still affected by their particular specific gravities, and are found existing in the lower and higher regions of these places, according to their respective weights.

In concluding, gentlemen, these few lectures on public hygiene and medical police, I cannot but express to you how superficially and inadequately I feel that I have treated these deeply important subjects; in fact, I have been enabled to give you only a syllabus of what should have been delivered on these matters, involving as they do, so much of the health, well-being, and comfort of the community; but in justice to the other necessary and more strictly professional parts of our course of lectures on forensic medicine, we have been obliged to confine ourselves to a mere summary of what we would, otherwise, have had much pleasure and interest in more fully discussing.

A CRITICAL ANALYSIS OF THE PRINCIPAL FACTS OF DISEASE.

(Continued from page 543.)

IRRITATION AND CONGESTION.

The red particles of the blood are endowed with physical properties which fit them for the fulfilment of a very important purpose in the mechanism of the circulation.

These minute solids are extremely elastic. When compressed between glass, they recover their form on the removal of the pressure, and rush through the serum with a motion which is independent of the containing fluid, some moving with more rapidity than others, some remaining stationary in the liquor sanguinis, while others bound off from those with which they may have come in contact. Their want of attraction for one another depends also on their elasticity.

As elastic bodies, the red particles receive a greater impulse from the heart than the liquor sanguinis. From their vast number, however, and the influence of capillary attraction, which is exerted between solids and liquids, the fluid is carried forward in an almost equal velocity with the solid portions of the blood.

Capillary attraction may be exercised between solids and fluids, as in the instance of the red particles and liquor sanguinis, above noticed; and in that of capillary tubes and liquids. Or, it may be exerted between closely approximated surfaces with or without the intervention of a fluid. When moist surfaces are put in apposition, the attraction is rendered more powerful; for then, owing to the intervention of a liquid, there is a double attraction exerted by the surfaces; for the fluid, and for each other; and therefore a closer approximation of the surfaces. Of this physical law the capillary vessels, when emptied of their globules and most of their liquor sanguinis, afford a striking example. Then, these vessels collapse, and many of them are no longer visible. In the tail of the tadpole, and in the web of a frog's foot, the capillaries appear somewhat flattened, as if formed of superimposed membranes, united at their edges, and merging, laterally, into the adjacent tissue. A dark, irregular line on either side appears to mark this union, which in many instances is lost when the vessels are emptied.

Not only the opposite sides of capillary tubes, but of vessels considerably greater in diameter, must be within the sphere of capillary attraction. This remark extends to the extreme veins and arteries, as well as to the lymphatic vessels.

The following simple experiment will afford some idea of the real diameter of a capillary vessel.

Let two pieces of paper be gummed together, or two gum wafers of different colours be stuck face to face, and the united edges cut even, and set up in the field of a microscope by the side of an injected capillary. It will be found that an apparent space exists between their conjoined edges; a space which is equal in width to the diameter of the injected capillary.

In fact, the opposite surfaces of capillaries are within the sphere of mutual attraction, even while the circulation advances, and the tendency which they have to approximate, exerts a principal share in regulating the capillary circulation. The elastic red particles, in traversing the capillaries, offer an effectual