AN ADDRESS ✓ ON THE MORBID ANATOMY AND PATHOLOGY OF CHRONIC ALCOHOLISM.

Delivered at the Opening of a Discussion at the Pathological Society of London, December 4th, 1888.

By JOSEPH FRANK PAYNE, M.D.,
Vice-President of the Society; Physician to St. Thomas's Hospital.

[Concluded from page 1277.]

MORBID CHANGES PRODUCED BY ALCOHOL IN VARIOUS ORGANS.

Since it is obviously impossible to speak of all the organs which may be altered, I shall confine my remarks to a few, especially the liver and the nervous system, taking the morbid changes in these parts as types of the effects produced in the organs generally.

Effects of Alcoholism as seen in the Liver.—It is generally recognised that one effect of alcohol is to produce accumulation of fat or steatosis in the liver. This change is produced especially by dilute forms of alcohol, and in those who are well fed. The explanation has already been suggested. Only one question occurs to me respecting this condition: Does it ever pass into cirrhosis? Are there not large livers, with a large amount of fat, which show commencing cirrhosis? Or does the fatty change in some way shield the liver tissues from the more serious and irritative action of the spirit? The accumulation of fat is, so far as it goes, evidence of the destruction of some alcohol, if the explanation given above be correct.

Cirrhosis of the Liver.—It would seem as if no pathological process were better known or explained in a more satisfactory way than this. It is generally accepted that concentrated forms of alcoholic drinks, brought into the stomach, are absorbed into the portal vein, and carried to the liver, where inflammation of the interstitial stroma is set up, by which new fibrous tissue is produced. In consequence of the pressure of this tissue, and its subsequent contraction, the liver cells are compressed and destroyed, and are found in various degrees of degeneration loaded with fat, yellow granules, and so on.

To this explanation I am inclined to demur. I would ask, Is a liver ever found with healthy hepatic cells and an inflamed stroma? In the very earliest stages of cirrhosis are not the cells decidedly degenerated? Is it not more reasonable to suppose that the injurious action of alcohol is exerted simultaneously on both parts of the organ; and that, if so, the parenchymatous elements, being more vulnerable than connective tissue, would suffer first? Dr. Lionel Beale, indeed, urged some years ago that the change is essentially atrophic, not inflammatory.

I am also led to raise this question by consideration of a certain very rare form of degeneration of the liver, which is really, I think, produced by alcohol, though the connection has not been recognised. I mean that called in England acute red atrophy. (In Germany the name "red atrophy" is often given to what we call the nutmeg liver.) It is generally admitted to be nearly allied to the acute yellow atrophy, but differs from it, in other respects besides colour. The organ is much reduced in size; the liver cells, as in yellow atrophy, show advanced degeneration and necrosis. Other parts of the organ are of a deep red colour, with little or no liver tissue, and consist chiefly of connective tissue and capillaries deeply engorged, inflamed with infiltration of leucocytes, and showing new formation of fibrous tissue. This short description, founded on a paper by Dr. Moxon in our *Transactions*, and on the only case which I have seen, proves, I think, that the same changes are displayed in an acute form, as cirrhosis shows in a chronic form. The connection with alcohol is perfectly clear, though it was not brought out by Dr. Moxon, nor has it been insisted on in the other cases brought before the Society. We have three cases in all; Dr. Moxon's (vol. xxiii), where two brandy bottles were found under the patient's pillow; Dr. Cayley's (vol. xxxiv), in a drinker of spirits; and Dr. Carrington's (vol. xxxvi), which occurred after hard drinking for six weeks. The last I had the opportunity of examining as a member of the Morbid Growths Committee, which gave it the same name as I have done. Dr.

Cayley, indeed, suggested that the atrophic process supervened on a chronic cirrhosis; but, taking the three cases together, it would seem that the parenchymatous and interstitial parts of the organ were concurrently affected; the former undergoing, as the usual law is, atrophy and necrosis; the latter showing ordinary inflammation. But if there was any difference in order of time, the parenchyma would be likely to suffer first. I suggest the same explanation for common cirrhosis, and shall return to the same point in speaking of the nervous system.

Another question of interest bearing on cirrhosis is why is it so comparatively rarely found in the bodies of drunkards. Peters found it in four or five cases only out of seventy persons who died from the excessive use of ardent spirits. What other factor is concurrent with alcohol in producing it? Is it ever set up by the action of any liquors other than distilled spirits or strong wine, such as sherry?

EFFECTS OF ALCOHOL ON THE NERVOUS SYSTEM.

While the functional disturbances produced by alcohol on the brain are the most familiar evidence of its action, and, when excessive, have long been recognised as the most deleterious of its results, the actual textural changes produced by it have only been demonstrated in comparatively recent times.

The demonstration of organic changes in the nervous system began, as was natural, with the brain, and with observation of alterations visible to the naked eye. I will first speak of changes in the meninges.

The dura mater has been very frequently observed to be thickened, the Pacchionian bodies largely developed. Vascular congestion has been frequently described, but the conditions immediately preceding death and the manner in which the necropsy is made influence so decidedly the amount of blood contained in this part that the observation has not any very great value. More rarely a special change of the dura mater has been described—namely, chronic pachymeningitis, sometimes in the form of the so-called pachymeningitis hemorrhagica, or hematomata of the dura mater. This curious condition has been explained by Virchow as produced by a combination of exudative inflammation with hemorrhage. It is certainly sometimes connected with atrophy of the brain. This is among the rarer results of alcoholic poisoning, though it is described by Lancereaux, Greenfield, Magnan, and others as occurring in cases of chronic alcoholism and delirium tremens, and is also found in chronic dementia and other cases in asylums. Without discussing fully the origin of this condition, I will only say that hemorrhage into the arachnoid cavity is certainly the most important factor, and capable alone of producing the appearances in question, as is shown by such cases as that recorded by Dr. J. W. Ogle, where the immediate cause was injury in an alcoholic person.⁵ Hemorrhagic pachymeningitis has also been produced artificially in dogs by poisoning them with alcohol in even as short a time as four weeks.⁶

The visceral arachnoid and pia mater must necessarily, for purposes of pathology, be considered together. Thickening and opacity are the most constant changes observed, but in certain cases there is much vascular congestion, with small patches of ecchymosis. But the one most frequent appearance in the sub-arachnoid spaces, as well as in the arachnoid cavity, and to a certain extent in the internal cavities of the brain, is excess of serum. This is so marked that those accustomed to *post-mortem* examinations would generally say that a drunkard's brain is a wet brain.

Now, it is hardly necessary to point out that a similar condition is very generally met with in the brains of old persons; it is a senile condition. And both in chronic alcoholism and in old age the cause of this accumulation of fluid is the same; namely, it comes from atrophy of the brain-substance. The convolutions look small, the sulci deep, and in most cases the pia mater is easily removed.

If it be granted that atrophy of the brain is at least a common result of alcoholism, though not a distinctive one, it yet remains for consideration what the nature of the wasting process is, whether one of simple atrophy, or some special form of degeneration leading to diminution of size.

The answer to this appears to be that there is no special kind

⁴ *Pathol. Trans.*, xxix, p. 1. The specimen is in the Museum of St. Thomas's Hospital.

⁵ Ogle, *Pathol. Trans.*, vi, p. 5. Also Prescott Hewett, same vol., p. 10.

⁶ Kremiansky and others, quoted in Magnan's *Alcoholism*, p. 15.

of degeneration. The nerve cells are sometimes said to be granular, but in general, no change is described, as at all characteristic of alcoholism. Some observers go so far as to say that the cortical grey matter is very little affected; and one (Wille) refers the degenerative changes almost entirely to the medullary substance. On these points we hope for information from those who have made cerebral pathology a special study.

In a few instances, however, more pronounced changes are met with in the cerebral cortex. The pia mater is adherent to the convolutions, portions of the grey matter being torn off with it. On microscopical examination, patches of degeneration and sclerosis are seen. The inner surface of the ventricles again presents a rough and granular appearance; sometimes with fibrous outgrowths. These are in fact the lesions found in the brain in cases of general paralysis or paralytic dementia.

The relation of chronic alcoholism to general paralysis is a difficult and abstruse question, on which different opinions have been expressed by different observers among those who have had large experience in such diseases. It is only in special practice or special institutions that such experience can be obtained. What I venture to say on this subject is therefore said rather in the way of suggestion.

That so called general paralysis, or paralytic dementia, not now a very uncommon disease, often has for one of its factors excessive indulgence in alcohol can hardly be disputed. But if I take the statistics of general paralysis on the one hand, I do not find any very large proportion of cases regarded as solely or mainly due to this cause, nor, on the other hand, among the sequelæ of final stages of chronic alcoholism, does general paralysis occupy a conspicuous place. The conclusion seems to be that general paralysis is distinct from chronic alcoholism, and that for the production of the former out of the latter some additional cause is necessary.

Such a cause I believe to be excessive functional strain. The three factors of general paralysis are alcohol, functional strain, and in many cases, congenital incapacity to bear strain; in short, a disproportion between functional activity and power of resistance, especially in the higher cortical centres and the tracts connected with them. I emphasise this suggestion because it appears to confirm the conclusion arrived at on other grounds, that the effects of alcohol on the nervous system, and even on the brain, are independent of its functional effect on the nerve cells, but are those of a tissue-poison, acting directly on the protoplasm of various parts. At the same time it remains rather difficult to understand why alcohol so seldom produces inflammation or sclerosis in the brain, the organ which is most susceptible to its physiological effects.

The general subject of the relation of general paralysis to alcohol is one on which I hope we may receive more information from those whose field of observation in asylums has included many cases of each disease.

Changes in the Spinal Cord.—I now pass to the changes produced by, or ascribed to, alcohol in the spinal cord. These are not numerous, or frequently observed. Before the period of microscopical examination, the spinal cord was universally said to be healthy in necropsies of alcoholic persons. Of late years a few cases have been recorded in which there was sclerosis, or degeneration of certain tracts, especially the posterior columns, or posterior part of the lateral column (Magan).

When attention was drawn to the occurrence of paralysis, especially in the form of paraplegia, in chronic alcoholism, it was thought naturally that this would be due to disease of the spinal cord, but subsequent research has not quite confirmed this expectation. More constant morbid changes have been found in nerves. Nevertheless, in a certain number of cases, alterations have been detected in both. When the alcoholism has passed into paralytic dementia, changes in the cord have been found accompanying the changes before described in the brain. At the same time we have cases (I speak from my own experience) of what is thought to be acute myelitis due to excessive drinking. Are there any records of *post mortem* appearances in such cases?

Changes in the Peripheral Nerves.—Although the actual changes produced by alcohol in the nerves have only lately been observed, the symptoms now referred to them have been longer known, though referred originally to a lesion of the spinal cord. Dr. Wilks was, I think, the first in this country to give a clear description of these symptoms under the name of alcoholic paralysis.

Here I must venture to depart a little from the plan laid down, and say a word or two about the clinical aspect of the nervous

disease, especially as it is as yet not universally recognised by the profession.

The earliest symptoms are disturbances of sensation, and, in the first place, hyperæsthesia. There may be peculiar sensation (paræsthesia), such as numbness, tingling, or feeling of pins and needles, or burning, and sensations of boring and stretching. There may be actual pain, but not usually continuous. Later on, all these disturbances give place to anæsthesia, which is often observed to be present in particular areas. Difficulty in locating sensation and retardation in the transmission of sensation have also been described. All these symptoms are evidently referable to cutaneous nerves, but the deeper nerve trunks and muscles are often tender on pressure. The special senses are very rarely affected. If we consider the phenomena relating to muscles, we find a very prominent symptom, and usually an early one, though sometimes absent, is inco-ordination and loss of muscular sense. The knee-jerk is lost at an early stage, and Dr. Gowers refers this phenomenon, apparently with justice, to loss of the muscular sense.

All these phenomena constitute the condition of alcoholic ataxia, which may come on before there is actual paralysis of motion, and may remain, as I can state from personal observation, when actual paralysis, once present, has passed away, though it is probably always accompanied by muscular weakness. It is distinguished from tabes dorsalis, or what is called locomotor ataxia, by several characters, especially by absence of all symptoms connected with the pupil of the eye or with the sphincters. Next, if the affection continue and become more severe, we have the stage of actual motor paralysis. In this there will be entire loss of motor power in the muscles, sometimes quite local, sometimes in all four limbs. The paralysed muscles soon lose faradic irritability, and become impaired in galvanic irritability.

Now I think it is quite clear that the symptoms, of which the above is a bare outline, might be referred to injury of peripheral nerves.

Take first the case of the cutaneous nerves, the function of which is mainly efferent or sensory. The first result of slight injury to a nervous structure, if it do not pass a certain degree of intensity, is to cause its substance to be more easily decomposed—that is, to produce an apparent, or, at least, temporary, exaltation of function, which, in a sensory organ, is expressed as hyperæsthesia. A continuance or higher degree of the same injury will produce total loss of conducting power or anæsthesia. Whether this injury affects nerve endings, or nerve trunks, or both, is a question not yet entirely decided. It is evident that paræsthesia or irregular sensation may also result from injury to sensory nerves.

Now let us consider the case of the muscular nerves (a term which I prefer to that of motor nerves, at least for the present purpose). These nerves have a twofold conducting power: one efferent, transmitting motor impulses; another afferent, transmitting the muscular sense. The sensory or afferent function is assigned to special fibres, which are said to have a special origin. This statement my knowledge is quite inadequate to enable me either to confirm or reject; but for the present purpose it is enough that there are fibres having this function. It would seem as if these fibres were affected by a slighter form of injury than that which is necessary to cause actual motor paralysis. At all events, an injury of these fibres would produce all the symptoms of ataxia, and an injury of the efferent motor fibres would cause paralysis.

Certain other symptoms, which sometimes complicate alcoholic paralysis, are explainable by similar injury of other nerves. One is acceleration of the pulse. This is very notable in many cases. In one of my own, which ended in recovery, the pulse was for a long time not less than 140, independently of occasional fever, and still more rapid pulses have been observed. In a case of a confirmed drinker, whose pulse was usually about 180, and who died of thrombosis of the portal and mesenteric veins, with hardened liver, I found after death nothing to account for the rapid action of the heart. It is clear that a slight degree of injury to the vagus nerve would, in the absence of other causes, be sufficient to account for this acceleration of the heart; but when this observation was made the connection was not thought of. Paralysis of the diaphragm, from affection of the phrenic nerve, may also occur.

It would not be enough to show that nerve changes would account for these symptoms. It must be shown that no other cause accounts for them, and that the nerve changes actually

exist. The only other conceivable cause of all the symptoms described would be an extensive lesion of the spinal cord, affecting both motor and sensory tracts. Such a lesion is not known to occur in these cases, and has in many cases been proved not to be present. Moreover, the supposed nerve lesions have been, in many instances, found in the mixed nerves, including both cutaneous and muscle nerves. In one instance, at least, similar changes have been detected in the trunk of the vagus (Finlay) when the pulse was 160. It is to Lancereaux that the credit belongs both of suggesting this explanation and of establishing its truth.

I will not take up the time of the Society or anticipate the remarks of those who are to follow, and are more competent than I am to speak on this matter, by quoting observations of peripheral neuritis in cases of alcoholic paralysis; but I will refer to those published by Lancereaux, Reginald Thompson, Dreschfeld, Duckworth, Finlay, and others in various publications. More especially in the *Transactions* of our own Society Dr. Hadden (vols. xxxvi and xxxviii), Dr. Hale White (vol. xxxvii) and Dr. Sharkey (this year) have described specimens having the same significance. I will only venture to speak of one point in the pathology of what is called neuritis, and this with reference to other forms of the same lesion, such as diphtheritic and the various toxic forms.

The changes described in the nerves thus affected come under the heads parenchymatous and interstitial. The first include cloudy or granular appearance of the nerve fibres, segmentation of the myelone and collection of it in round and oval masses, sometimes absence of the axis-cylinder, and other similar changes; in fact all the evidence of degeneration, ending in necrosis.

The interstitial changes are seen in the perineurium or endoneurium, either diffused, or mainly external. These tissues may show an increase in the number of nuclei, or infiltration with leucocytes, and are generally thickened. In some cases actual increase of connective tissue has been described. These changes are what are usually described as inflammation leading to hyperplasia.

Very generally, both these changes are found together, but sometimes one group of changes predominates, sometimes the other; and thus the lesion is sometimes described as degeneration, sometimes as inflammation, and there has been a sort of controversy as to by which name it should be called, and which should be regarded as the original or primary change. I would submit that the parenchymatous and interstitial lesions are both produced by the direct action of alcohol, and illustrate the general law that when a toxic or injurious agent affects a mixed organ of the body, it is likely to produce degeneration or necrosis of the parenchymatous elements (nerve, muscle-fibre, epithelium), and what is generally called inflammation (either of the constructive or suppurative form) in the connective tissue, just as in the liver. This does not exclude the possibility of there being a parenchymatous neuritis, such as has been observed in experiments on animals by Ranvier and others; in which there would be formation of new nerve fibres. But as the nerves have never been removed during life from cases recovering, but only after death from fatal cases, in which there was presumably no repair, the nerve fibres show pure degeneration or necrosis.

It is also to be remembered that the change found in certain parts of the nerves may be a secondary degeneration, caused by interruption of the nervous currents by lesion of the nerve at another point. But when interstitial change and nerve degeneration are present, it is not necessary to suppose that the nerve fibres suffer secondarily, being compressed by the hyperplastic connective tissue. On the contrary, there are instances in which the nerve degeneration must be the primary change, and the connective tissue change a consequence of it. For instance, this must be the case in the so-called secondary degeneration of conducting tracts in the spinal cord or nerves, in consequence of injury to the ganglionic tissue with which they are connected. It is clear that the break of communication will at first affect only the nerve fibres, and not the connective tissue surrounding them. Changes in this tissue, that is to say, sclerosis, perineuritis, or interstitial neuritis, must therefore be a consequence of the nerve atrophy. How this leads to connective tissue proliferation is a difficult question. But I have elsewhere attempted to show that it may be partly a consequence of the diminished resistance which favours overgrowth of the tissue which remains; and secondly, that when the nerve fibres are dead, the connective tissue deals with them as with a foreign body. It tends to form a barrier of fibrous tissue around them as if to encapsulate them.

In ordinary neuritis we could only prove which was the initial stage of the disease by examining specimens at different stages, which has not been done, so far as I know. Hence, since we do not know the necessary order of the changes, it is more reasonable, on the whole, to regard them as simultaneous results of the action of alcohol, and to speak of the whole process as alcoholic neuritis.

I can only just allude to the remarkable fact that similar nerve-changes have been demonstrated in chronic arsenic-poisoning, in lead-poisoning, in paralysis from bisulphide of carbon, and in the disease called kakke, while there is great reason to think that the nerve changes of diphtheria and other specific diseases are due to the same morbid process. All these will be forms of multiple peripheral neuritis.

Changes in Other Organs.—I have chosen the liver and the nervous system as typical instances of the injurious effects of alcohol on tissues; and there would be no time to speak of other organs in the same way. I can only, therefore, briefly mention what appear to be the most important points.

With regard to diseases of the kidney, one cannot but feel that the connection of different forms of Bright's disease with drinking requires further elucidation. The general belief in the profession certainly is, or was, that drinking to excess is a rather frequent cause of this disease. But Dr. Dickinson's observations and statistics tell so strongly against this view that further observations are needed if it is to be maintained.

The relation of alcoholism to diseases of the generative organs is a very interesting though little studied subject. One of the oldest beliefs respecting the effects of excessive drinking is that such habits diminish fertility in both sexes, but especially in the male. The Rev. Stephen Hales, in the eighteenth century, even sought to show that the natural increase of the population of London was seriously lessened by the use of distilled spirits. The number of christenings (taken as corresponding to births) in London fell off from 19,370 in 1724 to an average of 14,320 in the three years preceding 1750. Whether these statistics rest on a sound basis I cannot say, but statements to the same effect have often been made. It is also stated that procreation, when one or both parents are inebriated, results in the birth of idiotic or deformed children, and Dr. Langdon Down has brought some such cases before the Society. It has never been shown whether this depends on any organic change in the testicles or the semen, or on the temporary inebriation. A few observations have been made on the condition of the male generative organs by Lancereaux and others. Corresponding conditions in the female sex would, there is every reason to believe, be equally injurious to the offspring. Little positive information has, however, been collected as to the state of the generative organs in female drinkers. Dr. Matthews Duncan's able paper on this subject in the *Edinburgh Medical Journal*, April, 1888, probably contains all that there is at present to say.

The organs of respiration appear, from clinical observation, to be affected by alcoholism. Certainly we often meet with laryngeal and bronchial catarrhs which are chronic and obstinate, and with great probability referred to the direct action of alcohol. In connection with this it may be worth while to recall the fact that alcohol is actually excreted by the lungs, probably partly in an oxidised state, and may therefore have a directly toxic action. Further, arsenic, if given in long courses, seems to have a tendency to produce bronchial catarrh; and cantharidine injected experimentally under the skin of rabbits has produced acute laryngitis. *Post-mortem* observations have shown nothing definite on this point.

With regard to the influence of alcohol on the production of tubercle, the utmost divergence, and indeed contradictory opposition, of opinion prevails. Huss found tubercular phthisis to be rare in drunkards, and that has been the general conclusion drawn from *post-mortem* observations. It has even been thought that drinking freely checks the progress of phthisis, but of this I can find little evidence. On the other hand, the more general impression is that alcoholism is a frequent cause of consumption. On this disputed point we must appeal to the methodised experience of those who have special opportunities of observation. The only new fact in the discussion is, I think, the undoubted frequency of tubercular disease in the subjects of alcoholic paralysis.

Passing over many important and interesting subjects, I will only say a word or two on the relation of chronic alcoholism to the skin. Most of us are familiar with the kind of skin generally associated with advanced alcoholism—soft, smooth, satiny, gene-

rally pale, and sometimes waxy-looking. It appears to depend partly upon accumulation of adipose tissue under the skin, partly, perhaps, upon wasting of the skin itself, or of the epidermis. It is very much like the senile condition of skin. It is stated by Lancereaux to accompany fatty degeneration of the liver, or rather steatosis. I am sorry, however, I have no specimens of skin from alcoholic subjects. The association of chronic hyperæmia of the nose or other parts of the face, and of acne rosacea, with drinking habits, is too well known to need mention, except the expression of a hint that the frequency of such association has been exaggerated. There is only one other skin affection, so far as I know, which has been definitely attributed to the effects of drinking. It is a peculiar brown pigmentation, mottled and variegated, which has been described as occurring in alcoholic persons. It is singular that we had one case at St. Thomas's Hospital of a patient dying of cirrhosis of the liver combined with tuberculosis, in whom a piebald mottled appearance is described as having been present on the genitals. It appeared from the description to have been like the so-called leucoderma, consisting of white patches in the midst of skin showing excess of pigment; but it would be premature, I think, to conclude from a few coincidences that it was produced by alcoholism, since a similar condition certainly often arises without any such cause.

Eczema, psoriasis, and various other diseases have been ascribed, with little ground, to the effects of drinking. The only fact I believe to be established is that drinking habits make such diseases inveterate, and sometimes quite incurable. I have seen eczema in an alcoholic subject pass into general exfoliative dermatitis, on which treatment made absolutely no impression.

But time warns me, and I conclude, to make way for those members who are, I doubt not, going to bring before us facts and materials which will, we may hope, materially advance our knowledge of this difficult and important subject.

ABSTRACT OF PRESIDENTIAL ADDRESS

OR

A STUDY OF THE MICRO-ORGANISMS IN AIR,

ESPECIALLY THOSE IN SEWER AIR, AND A NEW METHOD OF DEMONSTRATING THEM.

*Delivered at the Annual Meeting of the Border Counties
Branch of the British Medical Association, held
at Penrith.*

By J. D. ROBERTSON, M.D.,
Of Penrith.

[DR. ROBERTSON made some preliminary observations on bacteriological methods, and strongly commended the study to the attention of general practitioners.]

I have chosen the subject of bacteriology for briefly addressing you to-day, and, in so doing, I shall confine myself principally to a study of the micro-organisms in air, sewer air in particular, and to describe a new means employed for the detection of those organisms.

Until quite recently micro-organisms were not believed to exist in air. In Dr. Burdon Sanderson's very able report to the Privy Council in 1870, he states: "Most observers have looked for germs in the atmosphere, but with no success." In Dr. Parkes's *Practical Hygiene*, edition of 1887, it is stated: "It is probable that the microscopic examination of air will give us in future more important information than even the chemical examination."

What was then thought probable has now been more than accomplished, for only a qualitative estimate of the micro-organisms was anticipated; now we have attained to a pretty accurate quantitative analysis.

Twenty-five years ago Pasteur tried the effect of air upon nutrient jelly, which he sterilised and placed in quarter-litre flasks and exposed them to the air of the Jura mountains at various heights. These experiments were not quantitative, and the condition of the air, disturbed or not at the time of the experiment,

would lead to variable results; the small size of the flask was also an objection.

Tyndall exposed 100 test tubes containing a sterile fluid medium to the air. This method of experiment, in addition to having the disadvantage of a fluid medium, was exceedingly troublesome to execute, and fallacious, as the results depended very much on the position of the tubes to the currents of air.

Fruedenreich and Miguel adopted the plan of aspirating a definite quantity of air through glass-wool, then mixing the glass-wool with sterilised fluid, which was subdivided and mixed in flasks of sterilised broth, with the view of isolating the organisms, so that each flask contained only one. In those experiments the fluid medium and subdivision led to error.

Koch was the first to employ solid media in the cultivation of the organisms in air. He employed dishes, coated with nutrient jelly, such as I show you, and exposed them to the air. This was still not a quantitative estimate, and the condition of the atmosphere at the time of experiment would lead to very varied results.

Hesse's method was the next improvement. It consisted in aspirating a given quantity of air through glass tubes 2 feet 6 inches in length, and $1\frac{1}{2}$ inch in bore, coated with sterilised peptone jelly. This did not suit my purpose for examining sewer air, as it was too huge for general application; besides the results vary according to the amount of wind at the time of the experiment. Dry, dusty weather gives an exaggerated quantity of colonies per litre of air, and wet weather the reverse.

In addition to those objections, it takes a very long time to aspirate such a quantity as would be necessary to allow of any practical deduction being made. In calm weather, however, and in places where the apparatus can be applied, it gives fairly accurate results, compared with more recent and accurate methods.

A valuable paper appeared last year by Professor Carnelly, Dr. Haldane, and Dr. Anderson, of Dundee, in which they estimate quantitatively the carbonic acid, organic matter, and micro-organisms in dwellings and schools. Hesse's method was employed, and showed that ten litres of open air often gave no results as to micro-organisms, at other times rather less than one organism per litre of air in the town of Dundee.

Professor Carnelly's experiments also show that there appears to be no relationship between the amount of carbonic acid and micro-organisms in the air, and that the number of moulds is usually less than that of bacteria; also that the purer the air, the nearer do the moulds and bacteria approximate in number. In dry, dusty weather in the town of Dundee, the number of bacteria to moulds were 15 to 1.

In the *Philosophical Transactions of the Royal Society of London* for 1887, Dr. Percy Frankland describes a new method of air examination, by aspirating a given quantity of air through glass tubes, such as I show you. A constriction is made in the tube at one end and a plug of glass dust, between two layers of glass-wool, is placed at this constriction. I shall designate that plug as Plug *b*. Another constriction is then made at the other extremity of the tube, at which a plug (Plug *a*), consisting of glass-wool only, is placed. This tube is then sterilised by heat at 160° C., for one hour, three days in succession, and kept in the iron box in which it was sterilised until it is used. The tube is then fixed to a stand, and connected by tubing with an air-pump of known capacity. At any convenient point between the glass tube and the pump there must be fitted on a mercury pressure-gauge, to allow of the air being aspirated at the same pressure as the external air. After a given quantity of air is aspirated in this way, the tube is removed, and broken at a point between the two plugs. The plugs are then separately mixed with a certain quantity of sterilised water, and a part of this water was used to make a plate cultivation in the usual manner. The defect of this method is the inability to mix the plug uniformly with the water, and the subdivision of the fluid.

Dr. Percy Frankland then resorted to the method of mixing the plugs in sterilised flasks of 300 to 400 cc. capacity, containing gelatine peptone. The results of this method were most uniform and satisfactory.

I have deviated from Dr. Frankland's method by mixing the plugs in liquefied nutrient gelatine, and then making plate cultivations with them. The advantages which presented themselves to me by this method were, that I not only could see and note better the particular appearances of the colonies as they developed than by looking from behind upon them, as in the flask method, but also have access to them for microscopical purposes, and avoid any fallacies that might arise from the subdivision of the plug.

The following fifteen experiments on sewer air have been con-